

Contract No. NAS9-10975
BEI Index No. B-S191-404020

NASA CR.

141692

CONTRACT FINAL REPORT

EXPERIMENT S-191

VISIBLE AND INFRARED SPECTROMETER

(NASA-CR-141692) EXPERIMENT S-191 VISIBLE
AND INFRARED SPECTROMETER Final Report
(Block Engineering, Inc.) 168 p HC \$6.25

N75-18671

CSCI 14B

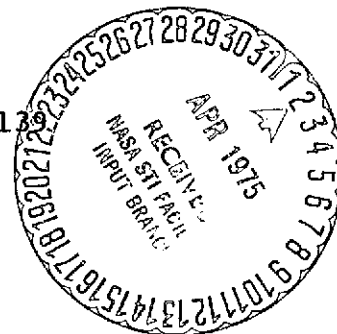
Unclass

G3/43 12480

June 1974



BLOCK ENGINEERING, INC.
19 Blackstone Street
Cambridge, Massachusetts 02122



CONTRACT FINAL REPORT
EXPERIMENT S-191
VISIBLE AND INFRARED SPECTROMETER

June 1974

Issued By



Eric R. Linnell
Mgr., R&QA Dept.

July, 1974
Date

Approved By



G. R. Pruitt
Program Manager

July, 1974
Date

BLOCK ENGINEERING, INC.
19 Blackstone Street
Cambridge, Massachusetts 02139

ABSTRACT

This Report describes the effort which resulted in the design, development, fabrication test and utilization of the visible and infrared spectrometer portion of the S-191 experiment, part of the Earth Resources Experiment Package, on board Skylab.

A brief description of the overall S-191 program is presented, as well as conclusions and recommendations for improvement of this type of instrument for future applications.

A detailed discussion of design requirements, instrument design approaches, and the test verification program are presented. Problems encountered throughout the program and the associated corrective actions are discussed.

Test results, including Flight Hardware calibration data are presented. A brief discussion of operation during the Skylab mission is included.

A complete listing of documentation associated with the program is included for reference.

CONTENTS

S-191 FINAL REPORT

	<u>Page</u>
SUMMARY	5
RESULTS	6
CONCLUSIONS AND RECOMMENDATIONS	6
PROGRAM INTRODUCTION	7
DESIGN SPECIFICATIONS	9
DESIGN APPROACH	13
MANUFACTURING, INTRODUCTION	17
TEST VERIFICATION, DEVELOPMENT TESTING	25
PROCUREMENT	33
FABRICATION	37
PROBLEMS AND CORRECTIVE ACTIONS	39
CALIBRATION	53
QUALIFICATION TESTING	73
ACCEPTANCE TESTING	79
POST LAUNCH ACTIVITIES	85
APPENDIX A - PROCUREMENT SPECIFICATIONS	87
APPENDIX B - REFERENCE LISTING OF DOCUMENTS169
DISTRIBUTION LIST.175

PRECEDING PAGE BLANK NOT FILMED

<u>FIGURE</u>		<u>PAGE</u>
1	. . Spectrometer Pictorial	20
2	. . Spectrometer Mounting	21
3	. . Optical Diagram	22
4	. . Short Wavelength Data	23
5	. . Long Wavelength Data	24
6	. . SWL Wavelength vs. Filter Position	54
7	. . LWL Wavelength vs. Filter Position	55
8	. . SWL Spectral Response	56
9	. . LWL Spectral Response	57
10	. . SWL NESR	58
11	. . LWL NESR	59
12	. . Si Channel Field of View	60
13	. . Pbs Channel Field of View	61
14	. . HgCdTe Channel Field of View	62
15	. . Peak Output vs. Radiance, Si @7300 Å	63
16	. . Peak Output vs. Radiance, Pbs @ 1.6 μ	64
17	. . LWL Response vs. Radiance @ 11.3 μ	65
18	. . LWL Response vs. temperature (5.82-11.5 μ)	66
19	. . LWL Response vs. temperature (8.3-16 μ)	67
20	. . Pbs Response vs. temperature	68

<u>TABLE</u>		<u>PAGE</u>
I	. . Performance Verification Matrix	12
II	. . Development Test Summary	27
III	. . Problems and Status.	39
IV	. . Summary of Instrument Performance	53
V	. . LWL Sensitivity at Peak Response Wavelength	69
VI	. . System Qualification Test Summary	74
VII	. . Acceptance Test Summary	80

SUMMARY

Under Contract NAS 9-10975, Block Engineering, Inc., Cambridge, Massachusetts was contracted to design, develop, fabricate, and test an IR and visible spectrometer for use in the S-191 experiment aboard Skylab.

This effort was carried out from July, 1970 through early 1973, with field support continuing through December, 1973.

The objective of the Infrared and Visible Spectrometer Experiment was to determine the usefulness and applicability of high spatial resolution spectrometry from space, both as a means of remotely sensing surface and atmospheric phenomena, and as a means of providing support to other sensors. This experiment was an extension to space of techniques already under study as a part of the Earth Resources Aircraft Program. It was felt there were potential applications to meteorology, geology, oceanography, and other disciplines.

The instrument to be built for this experiment was to utilize a filterwheel spectrometer with a scan rate of 1 scan/second through the visible/infrared regions 0.4 to 2.4 microns and 6.2 to 15.5 microns. The system was to have a 1 milliradian field of view which could be pointed at and held on small ground targets by means of a gimballed mirror Viewfinder/Tracker System. Other versions of the sensor would be used to acquire ground truth data at the time of spacecraft overflights. Such information; it was expected, would permit very accurate interpretation of the Skylab data.

The filter wheel spectrometer was designed, developed and fabricated by Block Engineering, Inc., Cambridge, Massachusetts. The Viewfinder/Tracker System was developed and constructed by Martin Marietta Corporation, Denver, Colorado.

The spectrometer system, as delivered to NASA, met or exceeded all design specifications and fully performed its mission.

RESULTS

The S-191 Experiment Visible and Infrared Spectrometer Flight Hardware met or exceeded all design and performance requirements. This conformance is demonstrated by the summary of instrument performance shown in this report, and in the Calibration, Acceptance Testing, and Qualification Testing data found in various sections of this report.

All problems which were encountered during this program were resolved, and appropriate corrective actions taken, as described in relevant portions of this report. All corrective actions were proven effective.

The equipment produced under this program achieved the stated mission objectives, and obtained the desired data.

CONCLUSIONS AND RECOMMENDATIONS

In retrospect, it would appear that very little would be changed if another vehicle became available and the scientific data review showed the desirability of obtaining more data of the type generated by the S-191 spectrometer.

The cryogenic cooler remains a question mark, and a more reliable device should be sought for this application. The entire system should be more thoroughly checked for out-of-spec interface conditions, and the possibility is strong that a more stable filter position ramp voltage generating system should be incorporated.

It is also strongly felt that a much more sophisticated calibration process should be instituted with improvements in the variety of calibration conditions, a greater volume of data and much greater precision of data readout. This would greatly facilitate the scientific analysis of data obtained and would more fully utilize the capabilities of the instrument. It is suggested that magnetic tape recording of both digital and analog data during calibration with subsequent computer analysis of this data would do much to make the final data review more meaningful.

PROGRAM INTRODUCTION

The design, development and fabrication program carried out by Block Engineering, Inc., Cambridge, Massachusetts, resulted in 3 sets of hardware and associated ground support equipment which met or exceeded all of the requirements of NASA contract no. NAS-9-10975.

The instrument is a scanning spectrometer utilizing a circular variable bandpass filter and scanning the ranges of 0.4 to 2.4 micron and 6 to 15.5 micron once each second. The sensing elements are a Si-PbS sandwich for the short wavelength region, and for the long wavelength region an HgCdTe detector cooled to liquid nitrogen temperature by a Sterling cycle cryogenic cooling engine.

The spectral data as well as reference temperatures and housekeeping data are converted to a PCM bit stream and recorded on magnetic tape for later retrieval and analysis.

The instrument was used to obtain data from specific selected targets by means of the associated View Finder Tracker System, which allowed the astronaut to "aim" the instrument and hold it on target.

The spectrometer also contains built-in self-calibration capabilities and fully adjustable references for greatest versatility. Outstanding sensitivity and resolution were obtained for this type of instrument and preliminary data review indicates that much useful data was obtained.

This report describes the design, development, fabrication and test effort which resulted in the successful completion of this portion of the program. The events are presented in chronological fashion so that the reader may have a general understanding of events as they transpired. Block Engineering also furnished some support for initial data review. The purpose of this review was to determine if any data anomalies existed which might indicate instrument malfunction and would dictate corrective actions on follow-on missions.

The results of this review are covered in the section entitled "Post-Launch Activities". Block Engineering is not involved in the review of the scientific data obtained from this experiment, and therefore cannot comment on the success of that aspect of the program.

It is the opinion of Block Engineering that the feasibility of utilizing this type of instrument in space to obtain the type of data desired has been amply demonstrated and that this hardware design has proven itself fully effective and reliable, fully achieving its mission objectives.

DESIGN SPECIFICATIONS

The following list of design specifications are those against which the S-191 spectrometer was designed and developed.

All of these design specification requirements were met by the flight hardware which was ultimately fabricated and delivered.

MAJOR FUNCTIONAL REQUIREMENTS

Required Components

The S-191 Spectrometer Flight Hardware shall include:

- a. Visible/infrared filterwheel spectrometer.
- b. Detectors and associated cryogenics.
- c. Electronics to operate a and b above.
- d. Electronics/data system to process detector and housekeeping signals for recording on the EREP tape recorder.

Spectral Coverage

- a. Short wavelength (SWL) channel
0.4 - 2.4 μ meter.
- b. Long wavelength (LWL) channel
6.2 - 15.5 μ meter

Performance Characteristics

- a. Spectral scan rate - once per second.
- b. Spectral resolution - $\Delta\lambda = 0.017$ to 0.3μ meter max, depending on wavelength.
- c. Spatial resolution - one milliradian when integrated with the V/TS.
- d. Sensitivity - maximum NESR $1.2 - 7.5 \times 10^{-5}$ watt/cm² - ster - μ , depending on wavelength.

Internal Calibration

Full internal radiance and wavelength calibration capability shall be supplied.

MINOR FUNCTIONAL REQUIREMENTS

Specified components

- a. SWL channel detector shall be a silicon/lead sulfide sandwich detector.
- b. LWL channel detector shall be a cooled HgCdTe detector.
- c. A closed cycle cooling engine shall be used to cool the HgCdTe detector.
- d. A miniature vac-ion pump shall be used to maintain the vacuum in the HgCdTe detector dewar.
- e. Circular variable interference filters shall be used as the spectral bandpass selection elements.

Control Circuits

Control circuits provided shall:

- a. Accept electrical power from MDA bus.
- b. Control radiance levels on the reference blackbody and on the internal heated blackbody calibration source.
- c. Switch on and off the SWL calibration and heated blackbody calibration sources.
- d. Insert and retract from the instrument field of view each of the three radiance calibration sources and the two wavelength calibration filters.

Output Signals

The following data and housekeeping signals shall be provided:

- a. "Ready" signal, which indicates cooled detector is at operating temperature.
- b. A voltage signal for each spectral channel proportional to the difference between target radiance and reference source radiance for the given channel.
- c. Voltage output as a function of filterwheel angular position.

d. Voltage levels indicating the positions of the radiance calibration sources and the wavelength calibration filters.

e. Calibrated voltage signals indicating the radiant output of internal radiance calibration sources and the thermal reference blackbody.

PCM Encoder

A PCM encoder shall be provided which:

a. Samples spectral channel signals and the filter position monitor voltage at 600 samples/second or greater.

b. Samples housekeeping data at approximately 20 samples/second.

c. Has 10 bit accuracy.

S191 Performance Verification Matrix (Flight Hardware)

Performance Parameter	EIS Design Value	Measured Value	Verification Test	Completion Date	Status
Spectral Range	.4 μ →2.4 μ 6.2 μ →15.5 μ	.39 2.5 μ 5.82 15.99 μ	Calibration Test	14 Jan 1972	Meets Re-requirements
Scan Rate	1 sec/scan(nom)	.984 sec/scan	Calibration Test	14 Jan 1972	Satisfactory
Spectral Resolution	<.017 μ (.4→.8 μ) <.035 μ (.7→1.4 μ) <.016 λ (1.2→2.4 μ) <.022 λ (6→12 μ) <.019 λ (8→15 μ)	.0125 μ (.39→.73 μ) .024 μ (.68→1.4 μ) .015 λ (1.34→2.5 μ) .019 λ (5.82→11.4 μ) .017 λ (8.3→15.99 μ)	Calibration Test	14 Jan 1972	Meets Re-requirements
f Number	f/2.7 (nom)	f/2.7	Calibration Test	14 Jan 1972	Meets Re-requirements
Entrance Slit	.025 X .025 in	.025 X .025	Inspection	15 Jan 1972	Meets Re-requirements
Instantaneous FOV	1mr X 1mr(nom)	.914mr X .914mr	Analysis	August 1971	Meets Re-requirements
Accuracy of CVF Central Wavelength	.005 μ (SWL) .015 μ (LWL)	.005 μ (SWL) .015 μ (LWL)	Calibration Test	14 Jan 1972	Meets Re-requirements
Power	<152 watts avg <200 watts avg (during Cal) <235 watts pk	<152 watts <200 watts <235 watts	Acceptance Test	15 Jan 1972	Meets Re-requirements
NESR	Fig 1b of EIS	NESR Curves of B-S191-404005	Calibration Test	14 Jan 1972	Meets Re-requirements

TABLE I

DESIGN APPROACH

Flight Hardware General Description

The S191 Spectrometer Flight Hardware consists basically of 3 modules. These are the Electronics Module (EM), the Infrared Spectrometer (IS) Module, and the Calibration Module. The calibration module is bolted to the front of the IS module.

The EM is designed to mount on the interior of the MDA wall. It contains the PCM data system, a line filter/limiter network, one main converter, and relays for switching power to the short wavelength (SWL) calibration lamp, and the heated black-body calibration source. On one face of the EM is a panel containing five connectors. These connectors interface with MDA power bus, the EREP C&D panel, the V/TS, and the IS.

The main structure of the IS module houses the entrance slit, foreoptics, collimating and focusing paraboloids, chopper, wedge filter wheel, gear train assembly, motor drive, and electronics package. The cryogenic refrigerator is attached to one sideplate of the main structure.

A HgCdTe detector-dewar assembly is mounted on the cold finger of the refrigerator and long wavelength radiation from the entrance slit is collimated by an off-axis paraboloid and then refocused by another onto the detector. A similar set of paraboloids focuses short wavelength radiation onto a Si-PbS sandwich detector. The SWL and LWL radiation are separated by a dichroic element which transmits the SWL and reflects the LWL radiation.

Spectral scanning is accomplished by rotating a multi-element circularly variable filter wheel in the optical paths.

Radiation in the two optical channels is modulated by a rotating chopper to enable use of ac signal processing methods. The electronics package consists of 3 virtually identical signal processing channels, a filter wheel position monitor channel, a main converter and motor power supply, temperature monitor networks, and calibration source control circuits.

The calibration module contains a calibration source wheel actuated by a stepper motor, and a wavelength calibration assembly driven by a torque motor.

The Calibration Module

The calibration module contains a 4-position calibration source wheel driven by a stepping motor, an integrating sphere, a SWL calibration source lamp, a constant current power supply for the source lamp, a wavelength calibration assembly, and a torque motor for actuating it.

The calibration source wheel contains an ambient temperature black-body calibration source, a heated black-body calibration source, an integrating sphere cap, and a clear aperture.

The stepping motor for actuating the calibration source wheel steps in increments of 90° , thus driving the calibration source wheel through a 1:1 gear drive in increments of 90° . Activation of the stepping motor is controlled by logic in the C&D panel.

The wavelength calibration assembly contains a polystyrene filter for LWL calibration, a BG36 schott glass filter for SWL calibration, and a clear aperture. Each of these positions can be swung into the instrument field of view by the torque motor, which is activated by logic in the C&D panel. The torque motor drives the wavelength calibration assembly through a 1:1 gear drive, and rotates it to maximum angles of $\pm 60^\circ$. Deactivation of the power to the torque motor allows the wavelength calibration assembly to return to the clear aperture position under the influence of a spring load.

The Infrared Spectrometer Module

The main spectrometer drive motor is a 3 phase 400 Hz ac motor which runs at a nominal 12000 RPM and drives the gear train. The gear train in turn drives the chopper and filter wheel at the appropriate speeds. The gears are alternately stainless steel and Vespel SP-31 (a DuPont product). The motor follower is a 52 tooth stainless steel gear driving a 122 tooth Vespel gear on the chopper shaft. For a motor speed of 12000 RPM this gives a chopper speed of 5115 RPM. Following the chopper are gear pairs of 30:122, 30:122, and 24:122 to drive the circularly variable filter (CVF) at 1.014 seconds per revolution.

The chopper has two annular regions, the inner one with 12 each blades and spaces for modulating SWL radiation at 1023 Hz, and the outer one with 36 each blades and spaces for a chopping frequency of 3069 Hz. The outer annular region is angled at 45° to the nominal plane of the chopper wheel to facilitate the incorporation of a reference black-body source into the system. The rear surface of the outer annular region is highly polished to maximize the reflectance of energy from the reference black-body source to the HgCdTe detector.

The circular variable filter (CVF) assembly is composed of 5 individual filter segments, each covering a different wavelength region. These are arranged into two annular rings, one ring for the LWL channels and the other for the SWL channels.

Two pairs of paraboloidal mirror are used for collimating the energy from the entrance slits and re-focusing it on the detectors.

The foreoptics module includes the dichroic beamsplitter and flat optic mirrors for splitting the incident beam and directing the two components in the correct directions, the SWL radiation being transmitted and the LWL radiation being reflected by the dichroic.

The reference black-body source is a conical black body which has its temperature controlled between 250° K and 325° K by the thermoelectric cooler. It is the reference against which the LWL incident radiation is chopped.

The HgCdTe detector is used for sensing the incident radiation in the LWL channels. It is mounted in a vacuum dewar and operates at cryogenic temperatures below 90° K. A miniature vac-ion appendage pump is attached to the vacuum dewar to increase the vacuum integrity of the dewar. The detector is maintained at cryogenic temperatures during operation by a closed cycle cryogenic refrigerator. The detector-dewar and refrigerator cold tip have been carefully designed with mating parts to provide maximum heat transfer.

The SWL detector is a silicon-lead sulfide sandwich detector. The silicon absorbs and detects radiation from 0.4 μ meter to 1.1 μ meter. Radiation of longer wavelength from 1.1 μ meter to 2.4 μ meter is transmitted by the silicon and detected by the lead sulfide underneath.

The Electronics

The electronics module (EM) contains the PCM data system, various relays, a line filter/limiter network, and a main power converter.

Other electronics in the IS module contain the signal processing circuits, the filter position monitor circuit, temperature monitoring circuits, a second main converter, voltage regulators, and the 400 Hz synchronous 3 phase motor power supply.

The HgCdTe, Si, and PbS detectors each have their own matched preamplifier located physically close to the detector. Following the preamplifier in the signal channels are linear AC amplifiers.

The output of the ac amplification stage of each signal channel is fed to a synchronous demodulator which performs full wave demodulation and produces a dc signal out proportional to source radiance. To perform this operation each channel has its own synchronous pick-up assembly and synchronous amplifier.

The dc signals out of the synchronous demodulators are filtered and band-passed in final preparation for sending to the PCM data system for digital encoding.

The filter position monitor circuit utilizes a synchronous pick-up assembly. This generates an alternating signal which is amplified, and then processed in the following way:

The signal is monitored and for every positive going zero crossing a short pulse is generated. Each successive pulse therefore, corresponds to the rotation of a blade or a slot in the chopper past the pick-up assembly. Each pulse is then used to trigger the generation of a single constant-width square-wave. The successive square waves are integrated to produce an output voltage proportional to chopper rotation. Since CVF rotation and chopper rotation are linearly dependent functions, the output then is an accurate measure of filter wheel angular position. The integrator is reset to zero once each rotation of the CVF by a signal pick-up monitoring the filterwheel rotation.

Temperature monitoring circuits are used to monitor several temperatures such as the reference black body, the ambient black-body calibration source and the heated black-body calibration source. Thermistors are used for this purpose and voltage signals which are linearly dependent on the temperature of the thermistor over the temperature range of interest are generated.

The main converters use 28Vdc power from the MDA which is converted to 20 - 30 KHz ac, and used to drive a transformer. The voltages necessary to operate the various circuits in the instrument are produced at the secondary outputs, where they are then rectified, filtered and regulated to provide "tame" dc power.

The main spectrometer drive motor is powered by the output of a 2.4 KHz oscillator which is divided by 6 in frequency and phase lagged 120° to produce 3 400 Hz outputs 120° apart in phase to drive the 3 windings of the motor.

MANUFACTURING

Introductory Description of the S-191 Spectrometer

The S-191 Visible/Infrared Spectrometer is a wedge filter device designed to perform controlled experiments in the spectral regions from 0.4 to 2.4 and 6.2 to 15.5 microns, in order to quantitatively evaluate earth resources sensing capabilities from orbital altitudes. This spectrometer consists of a spectrometer module/calibration module assembly, and a separate electronics module. (See Figure 1). The spectrometer assembly is mounted in a case on the outside wall of the MDA, (shown in Figure 2) and receives radiation from earth targets by means of a gimballed mirror and Cassegrain telescope system.

The Spectrometer Module

The spectrometer module contains the wedge filter, sensors, optics, drive mechanism and electronics required to sense the spectral data of interest and process the resultant signals. The sensing elements are a sandwich detector comprised of a Si substrate element over a PbS substrate element that is sensitive from 0.4 μ to 2.4 μ , and a HgCdTe detector mounted on a Sterling cycle cryogenic cooler for operation near 77° K that is sensitive from 6 μ to 15.5 μ .

Pertinent features of the S191 optics are illustrated in Figure 2. This instrument accepts an f/2.7 beam of radiation and, by utilizing a foreoptics assembly consisting of a dichroic and three flat mirrors, directs the shorter wavelength (SWL) portion of this radiation ($< 2.5\mu$) through a chopper onto the SWL entrance slit and the longer wavelength (LWL) portion of the radiation ($> 6\mu$) through a separate region of the chopper onto the LWL entrance slit. Radiation focused on the SWL entrance slit is then passed through the SWL portion of a mirror, field stopped, and refocused by a second paraboloidal mirror onto the SWL sandwich detector. Radiation focused onto the LWL slit is passed through the LWL segments of the rotating wedge filter, collimated by a paraboloidal mirror, field stopped, and refocused by a paraboloidal mirror onto the LWL cooled HgCdTe detector. The outputs of the three detector substrates are then processed to provide spectral data on the incident radiation.

The Calibration Module

Affixed to the spectrometer module is a calibration module (Figure 1) which allows in-flight calibration of the spectrometer module. This calibration module contains an integrating sphere with SWL radiant source for radiance calibration of the Silicon/ PbS SWL detectors over the .4 to 2.4 μ range, as well as extended blackbody sources for the radiance calibration of the

HgCdTe LWL detector over the spectral range of 6.2 to 15.5 μ . The cap to the integrating sphere and the two calibration black bodies are mounted on a wheel driven by a stepper motor for insertion into or retraction from the spectrometer field of view. On a separate wheel, actuated by a torque motor, are two wavelength filters which may be inserted into or retracted from the spectrometer field of view independently. One filter is polystyrene film for wavelength calibration of the LWL detector while the other filter material is BG-36 Schott glass for SWL calibration. Power and control signals to the calibration module are received from the spectrometer module to which it is mechanically attached. Diagnostic signals from the calibration module are output through the spectrometer module.

The Electronics Module

A separate electronics module provides regulated power, handles control signals and diagnostics signals, and processes analog signals for storage on a tape recorder. This module provides regulated power to the spectrometer module and feeds control signals from the Earth Resources Experiment Package (EREP) Control & Display (C&D) panel into the spectrometer module. Signals from the spectrometer module are processed by a PCM system in the electronics module for storage onto the EREP tape recorder. Additional signals from the spectrometer module are fed through the electronics module into the EREP C&D panel for monitoring of system performance.

In-flight Calibration and Operation

Prior to each usage in orbit, after stabilization of the cryogenic cooler, an auto-cal sequence is initiated in which the calibrated radiant sources and wavelength filters of the calibration module are sequentially inserted into the field of view of the spectrometer. This establishes baseline performance of the hardware. Data is subsequently taken from ground targets, roughly 400 meters square, acquired by the astronaut with the viewfinder tracker system (V/TS) to which the spectrometer is aligned. At the end of the ground target data pass, another auto-cal sequence is performed to determine shifts in baseline performance, if any.

Interface with an astronaut operator provides this instrument with a flexibility not otherwise achievable. E.g., astronauts were able to track alternate targets when prime targets were not visible. Real time decisions on target availability and desirability were afforded which would not have been practical under automated operation.

An example of the type of spectral data produced by this instrument is shown in figures 4 and 5. The data presented shows outputs as would be expected from an "Auto-Cal" sequence, with the calibration targets in place for the left hand sequence, and with the spectral filters in place for the right hand sequence. The Si channel is provided with two outputs at different gain settings so that unsaturated output can be viewed over a large temperature range.

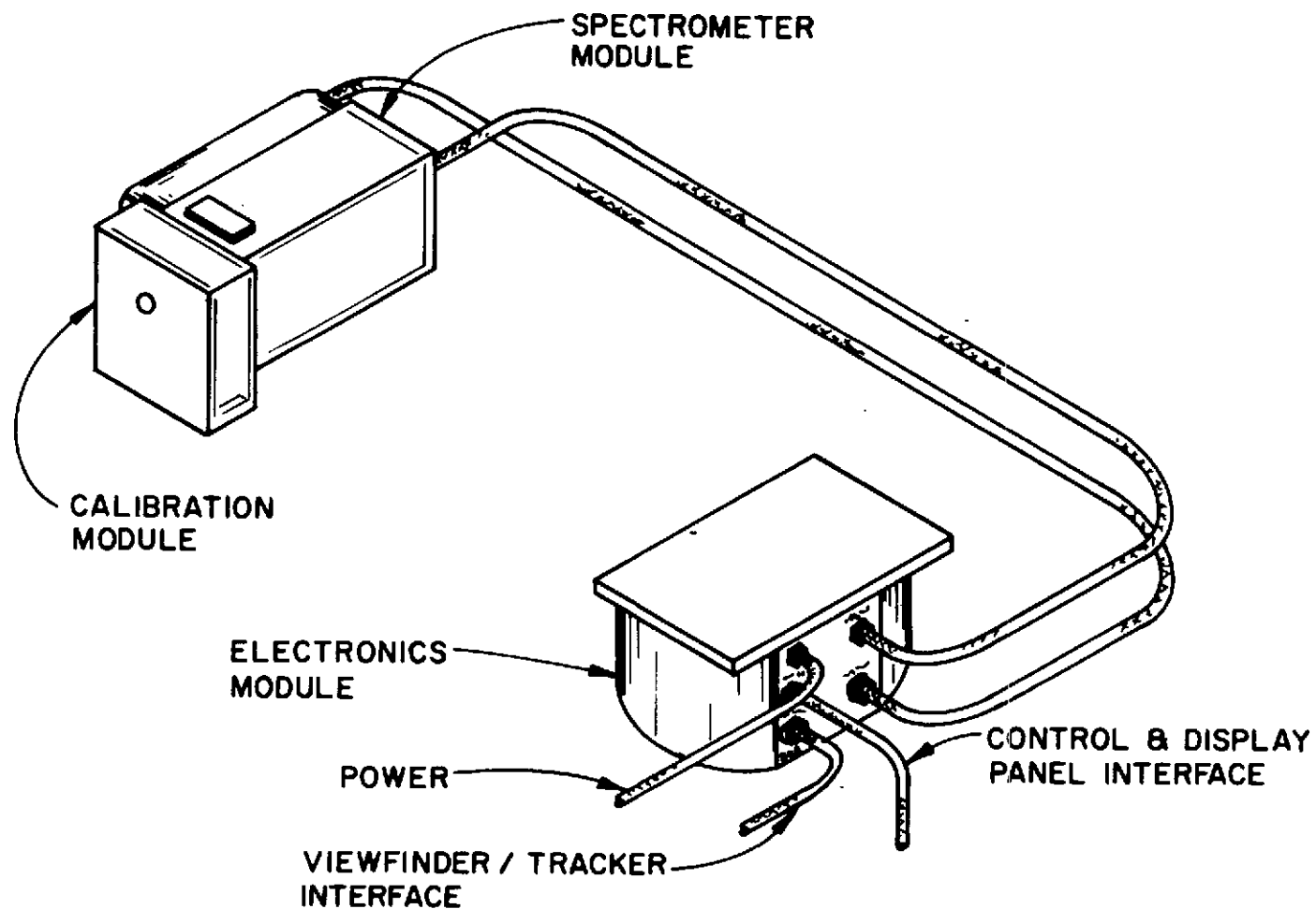


FIGURE 1
S191 SPECTROMETER

S191 VISIBLE AND INFRARED SPECTROMETER

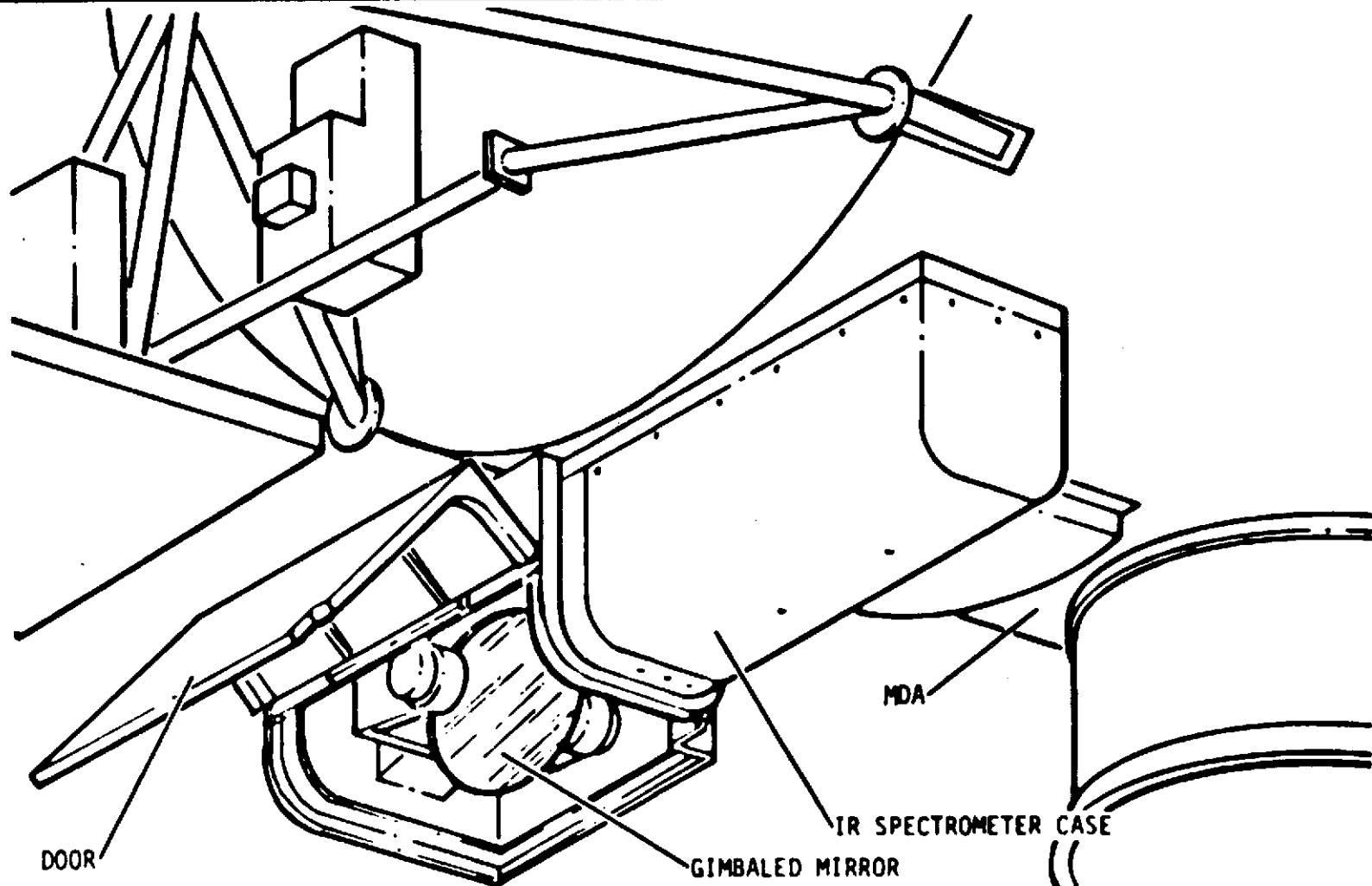


FIGURE 2

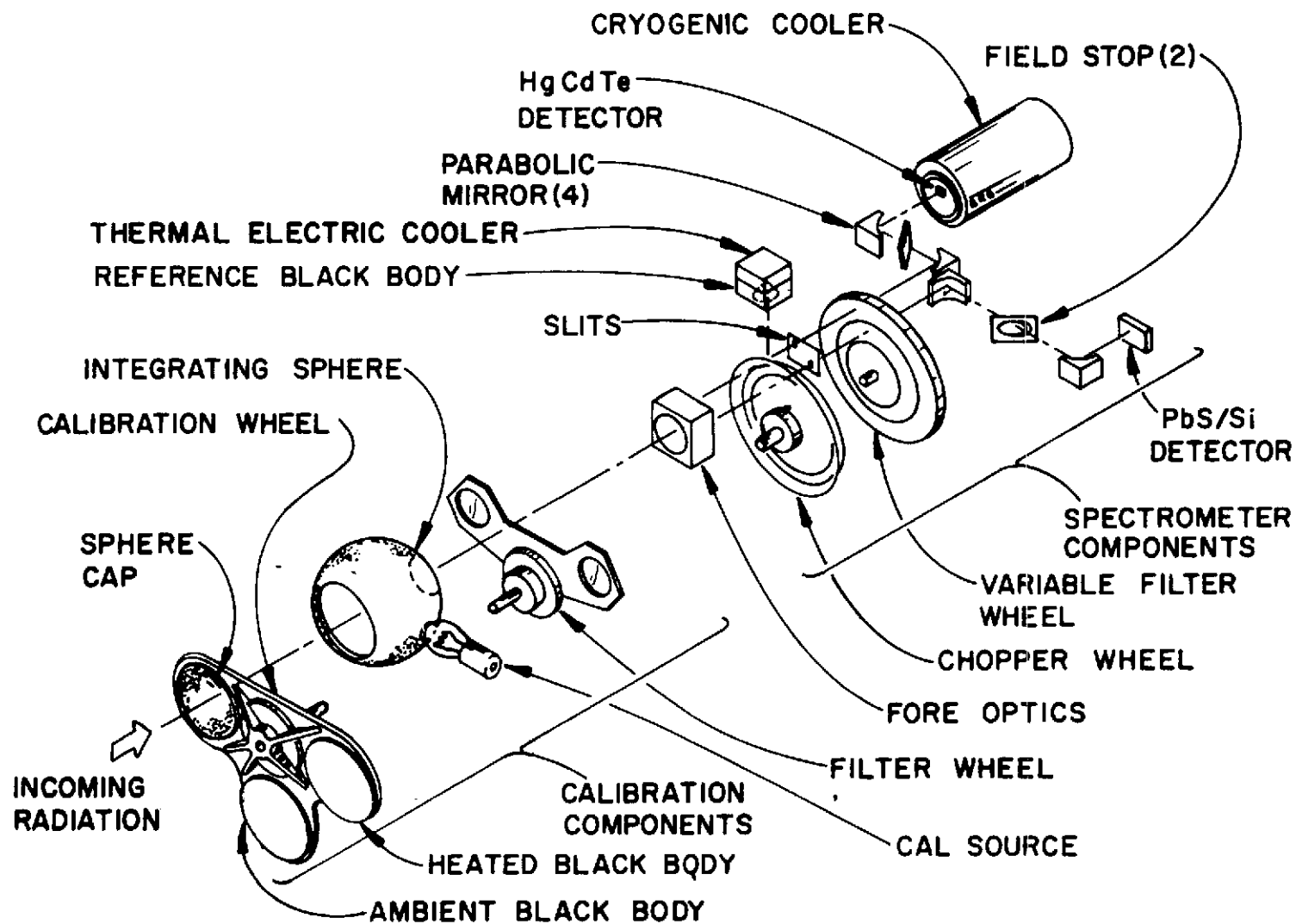
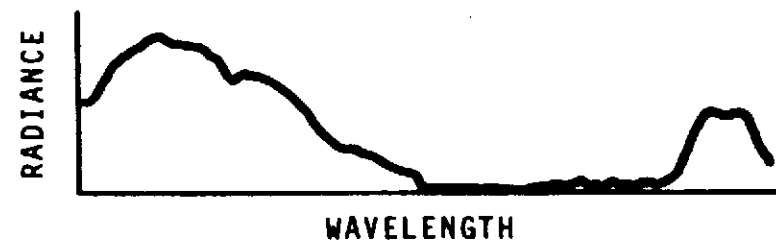
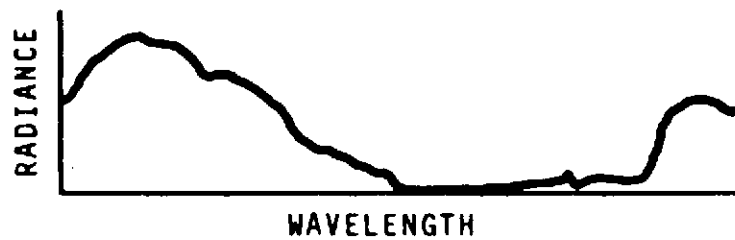


FIGURE 3 - OPTICAL DIAGRAM

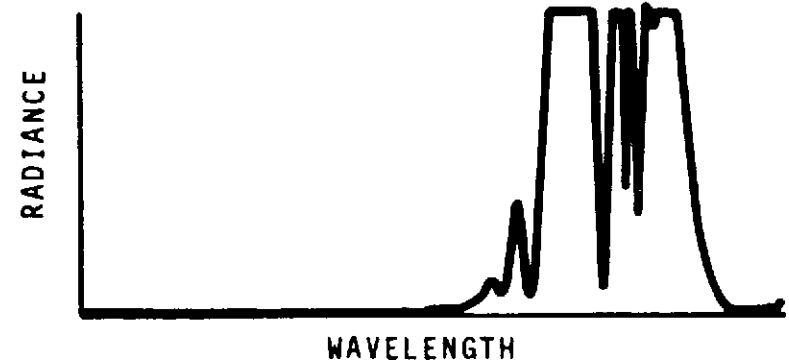
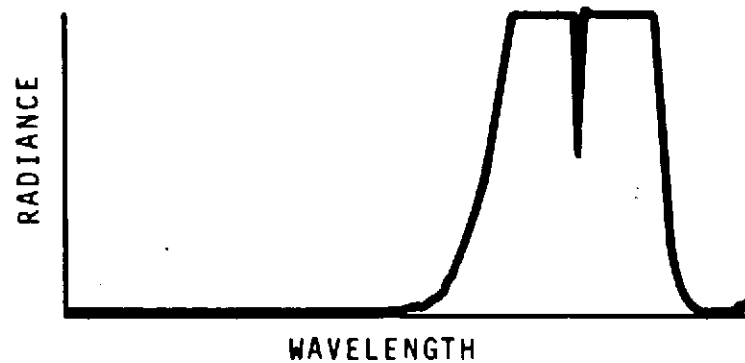
S191 VISIBLE AND INFRARED SPECTROMETER

S191 SHORT WAVELENGTH DATA

Si + Pbs (LOW GAIN)



Si (HIGH GAIN)



Si. (MEDIUM GAIN)



FIGURE 4

S191 VISIBLE AND INFRARED SPECTROMETER

S191 LONG WAVELENGTH DATA

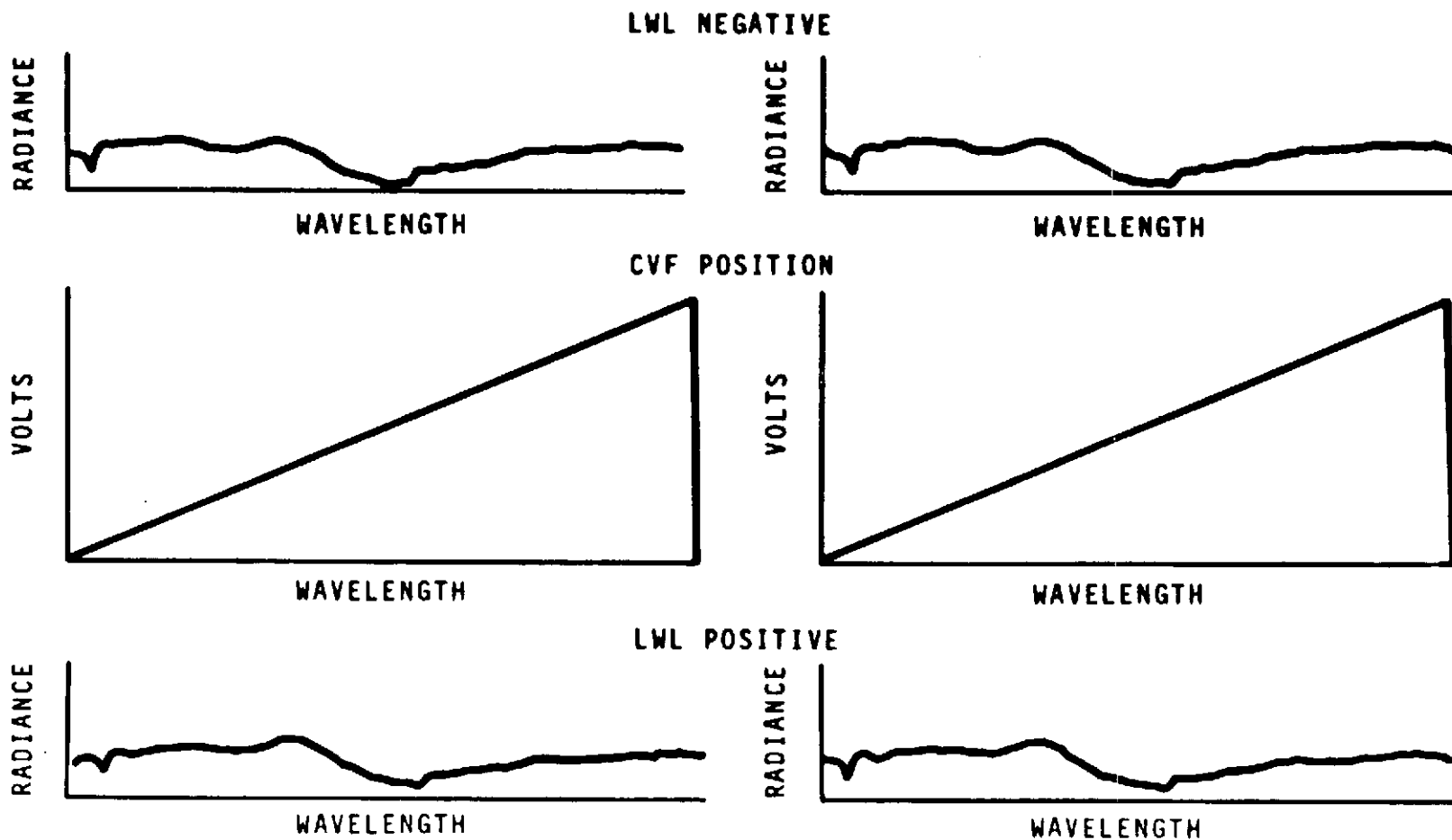


FIGURE 1

TEST VERIFICATION PROGRAM

Development Testing

Early in the S191 design program a number of development tests were performed to ensure that certain critical subassemblies met performance criteria imposed by system performance specifications and to gather specific data to verify design analyses.

Development testing consisted of the following tests:

a) Wedge filter assembly shock test. In this test a wedge filter assembly, incorporating a blank five segment wedge filter of the same substrate material as that used in the spectrometer design and the same mounting arrangement that was used in Flight Hardware, was shock tested to the specification limits of the End Item Specification, MSC-TF-S191-100, to verify the structural integrity of the design. On 13 November 1970, this assembly was tested axially and radially with nominal shocks of 20 g, 11 ms duration and 225g, 375 ms duration (corresponding to 380g shock spectrum). Upon completion of these tests the shock level of the short duration shock was increased to verify a design safety factor of at least 1.5. The most severe shock encounter was an axial shock of 640g, .6ms duration with no visible damage at the time of test. Inspection later revealed a crack under the retaining hub in a region which would not effect system performance. This crack was judged to have occurred during the final 640g shock, since the crack would have propagated across the filter had it occurred on a prior shock. Since no damage was incurred at shock levels up to 470 g's in both axes and since the crack that occurred at 640 g's did not effect system performance the test was deemed a success. Results of this test are included in development test report (DTR) B-S191-104001.

b) Sandwich detector spectral detectivity tests. A sandwich detector similar to that used in Flight Hardware was tested for spectral detectivity to verify expected detector performance. This development test article was received from the vendor on 17 November 1970 with vendor supplied data sheets. This detector was then shipped to Corona NOL to check the performance data of the sandwich detector elements. A comparison of NOL data with vendor data indicated an apparent error in the vendor's PbS data and raised some doubts about the NOL Si element noise data. The PbS discrepancy was resolved when the vendor indicated that the wrong PbS substrate and hence the wrong black-body to spectral conversion factors had been used. The Si noise discrepancy was resolved by remeasuring the quantity at BEI verifying the vendor data and indicating that the NOL data had not been compensated for amplifier noise. The net result of this test was to verify anticipated Si detector performance and to indicate that PbS detector performance was marginal but would

probably improve with a change in substrate material. Results of this test are included in DTR B-S191-104006.

c) Blackbody controller development tests. Tests were run on mockups of the reference blackbody and heated calibration source blackbody with their respective control circuits to verify that these blackbodies could be controlled to within $\pm 1^{\circ}\text{C}$ within 1 minute as required by the End Item Specification. Tests on the heated calibration source and controller were performed on 29 September 1970 indicating all temperature settings were controlled to within 1°C within one minute with an rms error of less than 0.5°C . Tests on the reference source and controller were performed on 17 November 1970 indicating all temperatures were controlled to within 1°C within one minute with an rms control error of less than 0.5°C . Results of these tests are included in DTR B-S191-104002 and B-S191-104003.

d) Fabrication Development of internal foreoptics. This test was performed to optimize fabrication techniques and assure required alignment of the involved optical surfaces. Towards this end a dummy foreoptics assembly P/N 930199 consisting of a mounting block and two mirror brackets was fabricated for evaluation. Although difficult to perform, the fabrication was adjudged to be achievable through standard machining practices. Next the assembly with dummy mirror and dichroic was evaluated for adjustability and basic design. It was determined that the assembly could be adjusted both for focal plane location and focal point separation. No serious defects in design were uncovered. In summary the fabrication and design of the foreoptics were adjudged acceptable. Results of this test are included in DTR B-S191-104007.

e) Dichroic development tests. Tests were performed on various thicknesses of gold and silver film deposited on glass to determine the optimum dichroic for the spectrometer. Gold coatings of 10 Å thickness to 150 Å thickness and silver coatings of 10 Å to 80 Å thickness were applied to microscope slides for performance testing. Measurements made by a local vendor of spectral reflectance and transmittance for each of these test pieces. Based on these measurements the optimum coating was chosen to be 50 Å of gold applied to a glass substrate. Results of these measurements are included in DTR B-S191-104004.

DEVELOPMENT TEST SUMMARY

Test	Purpose	Reference	Assessment
Wedge Filter Assembly Shock Test 1) 20g, 11ms sawtooth 2) 380g shock spectrum simulation	Verify structural integrity of wedge filter assembly	B-S191-104001	Successful
Sandwich Detector Spectral Defectivity Tests	Verify expected detector performance	B-S191-104006	Adequate performance verified
Blackbody Controller Evaluation Test	Verify blackbody sources and controllers meet temperature stability requirements of EIS (Control to within 1°C within 1 minute)	B-S191-104002 B-S191-104003	Successful
Fabrication Development of Internal Fore-optics	Optimize fabricate techniques and assure required alignment of involved optical surfaces	B-S191-104007	Design approach deemed acceptable
Dichroic Development Test	Establish optimum dichroic design	B-S191-104004	Design approach shown acceptable

TABLE II

S191 DEVELOPMENT TEST #1

Test: Wedge Filter Assembly Shock Test

Reference: DTR B-S191-104001

Purpose: Verify structural integrity of wedge filter assembly.

Approach: Using an uncoated filter (of some substrate and construction as flight type wedge filter) mounted in similar mounting assembly as utilized in Flight Hardware, subject the assembly to following radial and axial shocks:

- 1) Nominal 20g, 11ms duration sawtooth
- 2) Nominal 225g, .375ms duration 1/2 sine (corresponding to 380g shock spectrum)
- 3) $\geq 338g$, .375ms duration 1/2 sine to verify 1.5 design safety factor.

Test Values:

1)	R axis -	15g, 12ms
		22g, 12ms
	Z axis -	20g, 11.5ms
2)	R axis -	280g, 1.2ms
	Z axis -	300g, 1.1ms
3)	R axis -	440g, 1.1ms
		400g, .7ms
		450g, .7ms
		500g, .7ms
	Z axis -	470g, 1.0ms
		640g, .6ms

Test Results: No damage observed during test. Inspection after test completion revealed crack under hub adjudged to have occurred during 640g, .6ms shock.

Test Assessment: Successful since assembly survived 470g, .7ms pulse with no damage and ultimate damage would not have affected system performance.

S191 DEVELOPMENT TEST #2

Test: Sandwich Detector Spectral Detectivity Tests

Reference: DTR B-S191 - 104006

Purpose: Verify expected detector performance

Approach: Using prototype sandwich detector, have independent measurements made of spectral responsivity and detectivity to check detector vendor's data and verify expected detector performance.

Test Results: Vendor data peak Si D* @ 8000\AA = $8.2 \times 10^{11} \frac{\text{cm-Hz}^{\frac{1}{2}}}{\text{watt}}$

Independent measurement of Si₀D*
@ 8000\AA $7.2 \times 10^{11} \frac{\text{cm-Hz}^{\frac{1}{2}}}{\text{watt}}$

Vendor data peak PbS D* @ 2.0μ = $3.8 \times 10^8 \frac{\text{cm-Hz}^{\frac{1}{2}}}{\text{watt}}$

Independent measurement of PbS D*
@ 2.0μ = $3.0 \times 10^8 \frac{\text{cm-Hz}^{\frac{1}{2}}}{\text{watt}}$

Test Assessment: Adequate performance of Si detector verified.
Marginal performance of PbS detector verified with probability of improved performance in Flight type detector due to change in substrate material.

S191 DEVELOPMENT TEST #3

Test: Blackbody Controller Evaluation Test

Reference: DTR B-S191-104002, B-S191-104003

Purpose: Verify that reference blackbody source and heated calibration source blackbody with their respective controllers meet temperature stability requirements of End Item Specification.

Approach: 1) Using mockup of reference blackbody assembly with its controller, measure blackbody temperature one minute after turn on and at steady state for ambient temperatures of 48°C, 0°C, 25°C to verify that temperature is controlled to within 1°C within one minute for each of the 10 reference blackbody set points.

2) Using heated calibration source blackbody assembly with its controller, measure blackbody temperature one minute after turn on and at steady state to verify that temperature is controlled to within 1°C within one minute for each of the 10 calibration source set points.

Test Results: Reference blackbody

max error @ 25°C ambient	.536°C
rms error @ 25°C ambient	.35°C
max error @ 0°C ambient	.418°C
rms error @ 0°C ambient	.29°C
max error @ 48°C ambient	.746°C
rms error @ 48°C ambient	.60°C
Heated calibration source	
max error	1.0°C
rms error	.42°C

Test Assessment: Successful since blackbodies were controlled to within required limits.

S191 DEVELOPMENT TEST #4

Test: Fabrication Development of Internal Foreoptics

Reference: DTR B-S191- 104007

Purpose: Optimized fabrication techniques and assure required alignment of involved optical surfaces.

Approach: 1) Fabricate a dummy foreoptics assembly for evaluation.
2) Using dummy mirrors and dichroic evaluate adjustability and basic design.

Test Results: 1) Fabrication was adjusted to be achievable through standard machining practices.
2) Assembly was adjustable both for focal plane location and focal point separation. No serious design defects were uncovered.

Test Assessment: The Short Wavelength (SWL) field of view data (see figs. 12 and 13) indicated slight vignetting in the lower left quadrant. This vignetting was subsequently verified by visual observation through the Cassegrain system. Although this indicated the presence of a design defect, it was not severe enough to significantly degrade performance and was therefore deemed acceptable.

S191 DEVELOPMENT TEST #5

Test: Dichroic Development Test

Reference: DTR B-S191-104004

Purpose: Establish optimum dichroic for use in spectrometer

Approach: Fabricate dichroics of glass substrates with gold or silver coatings deposited in various thicknesses from 10Å thick to 150 Å thick. Evaluate spectral transmittance from .4μ to 2.4μ and spectral reflectance from 6μ to 16μ to establish optimum dichroic coating.

Test Results: Optimum coating was determined to be 50Å gold applied to glass substrate. Transmittance exceeded 35% over .4 to 2.4μ range and reflectance exceeded 50% over 6 to 16 range.

Test Assessment: Dichroic design approach was marginally acceptable. Better results were eventually obtained with OCLI coating of 50Å gold which apparently was due to more uniform coating.

Procurement

Since virtually all of the components used in the fabrication of the S-191 spectrometer were purchased from outside vendors, a major portion of the early program effort was involved with procurement. This effort required and received the close cooperation and coordination of the Engineering, Quality Assurance and Reliability, and Purchasing departments. Purchasing specifications were written, vendor capabilities were evaluated and vendor surveys run, samples were tested and all received parts and materials were 100% inspected and/or tested to assure conformance to the specification and purchase order requirements.

Several of the major procurements are worthy of further note, and will be described in more detail in the following paragraphs.

General Procurement Requirements

Several general procurement specifications were created which were used to convey program requirements not directly related to a specific product. These were: B-S191-8001205, "General Provisions for Subcontractors"; B-S191-8001206, "Special Provisions for Subcontractors"; B-S191-8001213 "Quality Assurance and Reliability Requirements"; and B-S191-8001216 "General Environmental Requirements for Subcontractors". Copies of these specifications are to be found in Appendix A of this document.

The Pulse Code Modulation System

The technical and performance requirements for this system are fully described in purchase specification B-S191-8001202 (see copy in appendix A). Specific portions of MSC-KA-D-68-1 which were applicable to this subcontract were included in B-S191-8001204. After initial efforts to place this subcontract with one vendor failed during final negotiations due to drastic price increases and exceptions taken to specification requirements, the order was placed with EMR Telemetry in Sarasota, Florida. Three units were supplied, designated as EMR part number POA B4050. No significant problems were experienced with this vendor or his product other than those indicated in the section entitled "manufacturing - fabrication - problems and corrective actions. This same vendor also supplied the decommutation equipment for the GSE, EMR part number 2746. No difficulties of any kind were experienced with these units.

The Circular Variable Filter

It was recognized during the proposal and negotiation phases of this program that there was only one viable vendor for the segmented wedge circular variable filter covering the large spectral range required. This vendor was Optical Coating Laboratory, Inc., Santa Rosa, California. The purchase specification issued for this unit was B-S191-8001201 (see Appendix A). One unit was purchased as an uncoated substrate for testing, (see description in section on development tests) while 5 flight type units were delivered. No difficulties were experienced with these units with the exception of the cracking of one unit during qualification testing (see the section on "problems and corrective actions"). This problem was fully resolved and the item considered qualified.

The Short Wavelength Detectors

These detectors were designed as a "two-color" sandwich, with a silicon unit in front of a lead sulphide one. This configuration provided for a common optical axis. The specification for this device was B-S191-8001210 (see Appendix A). Several potential vendors evidenced interest in this device and the procurement was finally placed with Opto Electronics, Peteluma, California. Although there was some initial confusion due to problems in measurement correlation (see section on development testing) this difficulty was quickly resolved and the units supplied were found to be fully satisfactory. Late in the program a spare unit was taken from stores to be used for refurbishment, and it was found that the sensitivity had degraded from initial measurements. It was determined by various investigations that this was due to being stored in a non-controlled environment which allowed high humidity to penetrate the detector enclosure. Future procurements required a hermetic seal on the package, and no further problems were experienced.

The Long Wavelength Detector

The long wavelength detector posed a particular challenge, for two reasons. First, the package design was unique, utilizing a metal-glass composite structure. In order to allow for mounting and demounting of the dewar on the cryogenic cooler, an internal "plug" was precisely located which would slip-fit into a cup on the cold finger of the cooler. The plug and cup were of dissimilar metals so that when the cold finger cooled there would be a tight fit between the two, providing maximum thermal

transfer. Secondly, the detector characteristics were of a "state-of-the-art" character, both in peak responsivity, and in the response required at 15.5μ . A procurement spec was written for this device, B-S191-8001218 (see Appendix A). Initial negotiations with a local vendor well known for HgCdTe detectors failed to produce results, and the subcontract was placed with Texas Instruments, Component Group (later Equipment Group), Dallas, Texas. A long series of problems were encountered by this vendor in the fabrication of the required assemblies. At times these problems threatened to impact the program, and several visits were made to the vendor's facilities by Block Engineering and NASA personnel. All problems were eventually resolved and the required units delivered which met specification requirements. The problems which were experienced can be briefly described as follows (see also section on "Problems and Corrective Actions"):

- (a) Mechanical. During qualification testing for shock and vibration failures of internal leads were experienced which resulted in redesign to provide heavier leads with greater strength.
- (b) Electrical. Meeting both the D* and 15.5μ response proved to be difficult. First, there was a limited amount of material available which showed promise of meeting specs at all. Secondly, there was unexpected degradation during some of the processing steps. The requirement for a bake-out of the metal dewar and the need to keep the detector from seeing too much heat had to be balanced, and some new process techniques developed. Thirdly, there was a long lag time between the time when a die was committed to a dewar and the time the finished assembly could be measured, which meant that if the completed unit was not satisfactory there was a long recycle time.
- (c) Organizational. Compounding the technical problems was the fact that the group which was producing the assemblies at Texas Instruments was reorganized and moved both physically and organizationally. In spite of all these difficulties the detector which was finally committed to the Flight Hardware was an outstanding unit with exceptional characteristics, and helped the final instrument produce results well beyond specification requirements in the long wavelength region.

The Cryogenic Cooler

During the proposal and negotiation stages of this program it was made clear that NASA desired Block Engineering to use a

model MK-XV "Cryomite" manufactured by the Malaker Corp., High Bridge, N.J. This unit had already been designed into the S-192 experiment, and it was felt this would be an overall cost savings with only one component qualification program required for both experiments. Block Engineering was not happy with the design of this cooler from the standpoint of removing heat and transferring it to the MDA wall, as well as for some other considerations. Efforts were made to work with a vendor who had a unit that separated the compressor and cold head, and would therefore allow mounting the compressor, where most of the heat was generated, directly on the MDA wall plate. This vendor, however, was not able to furnish a functional unit after spending some time working at it, and the effort was terminated. A procurement spec was written, B-S191-8001217 (see Appendix A). A Malaker Cryomite, Mark XV-SS-1A was subjected to the Component Qualification Test required by Block Engineering procedure B-S191-403061. The results of this test, as reported in test report B-S191-404001, indicated that the cooler met all requirements as specified. Efforts of Block Engineering to obtain more detailed and specific information on this cooler met with failure as the vendor had intense feelings as to the proprietary nature of his product. Nevertheless, an acceptance test procedure was developed, and several units were accepted at the N.J. plant by a Block Engineering representative.

When qualification testing of the completed S-191 qualification hardware commenced, a series of problems developed with the cooler, making it inoperative. The vendor performed a refurbishment which was designed to make the unit more reliable at anticipated operating temperatures, and testing of the assembled hardware continued. A second component qualification test was developed for the cooler (as refurbished by Malaker) and this test, run to BEI procedure B-S191-407007, is fully reported in Test Report B-S191-404009. Suffice it to say here that the unit malfunctioned at about 56 hours, recovered and ran normally, and then failed completely at about 200 hours. The cooler was taken to the Malaker Corp. for failure analysis, and it was determined that the cause of failure was abnormal brush wear. At this point a serious problem arose. The Malaker Corp. was in serious financial difficulty, threatening bankruptcy. This meant that the Malaker Corp. was not in a position to provide the needed failure analysis or effective corrective action. Because of this, NASA JSC undertook the effort of additional cooler development, refurbishment and qualification. This was done with the support of Block Engineering personnel and with the assistance of one former employee of Malaker Corp. The coolers for both S-191 and S-192 experiments were refurbished, and this effort is fully described in NASA Internal Note JSC-08056. The result was coolers which successfully performed their Skylab mission. The above is fully detailed in Block Engineering Historical Report B-S191-404010. Further details on flight cooler performance are given on page 85.

FABRICATION

Three fully functional hardware systems were produced for the spectrometer portion of the S-191 experiment.

The first unit was fabricated as an Integration Functional Test Unit. It was a full fidelity spectrometer system and differed only minimally from follow-on hardware. It was manufactured using "red-line" drawings to expedite program availability, and thus served the additional function of a pre-production or prototype model.

After this unit had served its purpose in Integration Functional Testing, it was returned to Block Engineering and re-manufactured into a Helicopter Unit. The major modifications were the removal of the cryogenic cooling engine and substitution of a liquid nitrogen cooled dewar, and the removal of the wavelength calibration elements and substitution of focusing lenses. This unit was later helicopter-mounted and used to obtain underflight real time data for comparison with Skylab data.

The second system to be fabricated was the Qualification Test Unit, and was made to conform to all flight requirements. This system was used for all qualification testing and for all retesting as a result of corrective actions. Upon successful completion of all qualification testing, the system was returned to Block Engineering and fully refurbished into a Flight Back-up Unit. This refurbishment consisted of the replacement of all elements of the system which might have been subjected to degradation as a result of the stresses imposed during testing. The system was also brought up to final flight configuration by the inclusion of all approved modifications.

The final system to be fabricated was the Flight Unit. This unit was manufactured to include all corrective actions determined to be necessary as a result of qualification testing. After initial system integration and testing on the MDA, the spectrometer system was returned to Block Engineering for incorporation of several modifications requested as a result of continuing test evaluation. This Flight Unit was then returned for re-insertion on the MDA. It has continued to perform as required throughout all systems verification testing and was the system ultimately launched with the Skylab on 14 May 1973.

Two complete Ground Support Equipment systems were fabricated, as well as one modified system. The complete GSE systems provided all power supplies for operation of the S-191 spectrometer, and also contained a digital-to-analog convertor to decode the output of the S-191 pulse-code modulation system. All data outputs could be addressed and measured in both analog and digital format, and a number of additional diagnostic outputs were also provided.

The modified GSE system was similar except it contained no power supplies and did not have a DAC. Both versions also contained full control facilities for all variable instrument functions.

The following listing describes all problems detected during manufacturing and test operations and describes their analysis, corrective actions taken, and verification of these actions.

There are no open problem reports, and the flight hardware has successfully completed its mission.

Problems and Status

Problem	Classification	Status
Cryogenic cooler -- performance degradation at 120° F, 60° F; brush failure (FIAR's 5303, 5304, 5321, 5324, 5326, 5327, 5337, 5341, 5345, S-191-8018, WRE-056	Major	Closed by refurbishment by TTB, PPD, NASA/JSC (See internal note JSC-08056)
Detector-dewar assembly-breaking of internal leads; detector degradation (FIAR's 5339, 5344, S-191-8009, S-191-8076)	Major	Closed
Circular variable filter -- cracked during qualification testing (FIAR 5340, 5342)	Major	Closed
Integration sphere and cap -- broken during qualification testing (FIAR's 5325, 5338, 5343)	Minor	Closed
PCM encoder -- clock failure; defective solder joint (FIAR's 5301, 5336)	Minor	Closed
Gear train ceased to operate during thermal vacuum (FIAR 5302)	Minor	Closed
EMI nonconformances (FIAR 5305)	Minor	Closed per waiver S-191-9
External dimensions out of ICD limits (FIAR 5332)	Minor	Closed per IRN 18 to MSC-01008
Total weight out of EIS limit (FIAR 5333)	Minor	Closed per waiver S-191-13

TABLE III

Problem	Classification	Status
Cal lamp current out of spec (FIAR 5334)	Minor	Closed
Double reset pulse occurring at random (FIAR's S-191-8075, S-191-8125)	Minor	Closed by incorporation of redesign
Qualification Hardware lack of sensitivity (FIAR 5328)	Minor	Closed per waivers S-191-7 S-191-10, S-191-11
Damage connectors; unmarked connectors (FIAR S-191-8023)	Minor	Closed
Improper test limits and conditions (FIAR's 5306 → 5320, 5322, 5323, 5329 → 5331)	Minor	Closed
± 12 Volt Output anomaly (FIAR 5335)	Minor	Closed
Ready light flicker at turn-on during On-Module test (FIAR S-191-8036)	Minor	Closed
Anomalous reading of vac-ion pump current during On-Module test (FIAR S-191-8077)	Minor	Closed
Recorded data anomalies during On-Module test (FIAR's S-191-8078, 79, 80, S-191-8120)	Minor	Closed

TABLE III (concluded)

MAJOR PROBLEMS AND CORRECTIVE ACTIONS

Component Failures

A. Cryogenic Cooler, Malaker Corp. Model Mark XV

Block Engineering Drawing No. 64100

Reference FIAR's 5303, 5304, 5321, 5324, 5326, 5327, 5337, 5341, and 5345. Also S-191-8018 and WRE-056.

Description of Problem:

1. Initial performance at acceptance test -- satisfactory
2. In-use exposure to max. temp. (+120°F) -- temporary or permanent degradation of cooling capacity
3. In-use exposure to min. temp. (+50 to +60° F) temporary degradation of cooling capacity.
4. Operating life at nominal conditions -- loss of cooling capacity or reduction of insulation resistance motor windings to case.

Failure Analysis and Corrective Action

Undertaken by Engineering and Development Directorate of MSC due to business failure of manufacturer.

1. Failure mechanism identified as excess motor brush wear and contamination of working gas.
2. New motors procured with all parts treated to reduce contamination and using long life brushes.
3. Lubricants on moving components changed to reduce outgassing contamination.
4. Coolers reassembled with new motors. Qual. test completed 6/8/72, qual. unit still exhibited temporary degradation at +60° F.
5. Flight Unit delivered to Block Engineering on 6/12/72.

Status: Closed. Refurbishment program reported in JSC internal note JSC-08056.

MAJOR PROBLEMS AND CORRECTIVE ACTION

Component Failures

B. Detector-Dewar Assembly, Long Wavelength.

Texas Instrument MCT-071

Reference FIAR's 5339, 5344, S-191-8009, S-191-8076

Description of Problem:

1. Mechanical breaking of internal detector and thermistor leads when subjected to shock and vibration stresses.
2. Degradation of detector sensitivity with use over time.

Failure Analysis and Corrective Action

1. Internal lead structure improved by addition of termination pins embedded in glass to facilitate connection of internal wires to painted conductive strips.
2. Change of internal connecting wires from 5 mil. diameter gold kovar to 10 mil. diameter platinum.
3. IR Spectrometer electronic circuitry modified to remove bias voltage from detector unless cooled to operating temperature. Bias current at higher temperatures defined as cause of degradation.

Status: Closed

MAJOR PROBLEMS AND CORRECTIVE ACTIONS

Component Failures

C. Circular Variable Filter, O.C.L.I.

Block Engineering Part No. 631392D

Reference FIAR: 5340 (FIAR 5342 related)

Description of Problem:

1. Part of outer segment of CVF cracked but did not separate from rest of filter.
2. Several chips were liberated from crack area, lodging in spectrometer gear train.
3. Crack was detected following series of environmental exposures, making determination of cause of crack difficult.

Failure Analysis and Corrective Action

1. The possibility existed that failure was caused by a docking shock test which contained peaks substantially in excess of nominal. A retest was performed using another filter with carefully controlled shock levels with no failure resulting.
2. Thermal stresses could have precipitated this failure, and another filter was tested by soaking at -40° F with no failure resulting.
3. The facilities, processes, procedures, and records of the vendor, OCLI, were investigated for any evidence of nonuniformity or other anomaly, with negative results.
4. Analysis and inspection of failed filter at NASA/MSFC indicated crack due to thermal exposure.
5. Special handling and inspection requirements will apply to all future filters.

Status: Closed

Minor Problems

A. Test Anomalies, FIAR's 5306 thru 5320 5322 and 5323

A number of functional test readings failed to meet the specification limits. This was caused by the use of a procedure initially intended for room temperature in conditions which called for high and low temperature testing. Also some erroneous readings were caused by improper test equipment settings. All specifications and procedures were revised to cover actual conditions. (Status -- closed)

B. Test Procedure Deviations FIAR's 5329 thru 5331

During calibration, it was found that several procedure steps called for conditions which could not be attained or operations which were impractical. The procedures were later revised to correct these problems. (Status -- closed)

C. 12 Volt Power Supply Deviations. FIAR 5335

Following vibration test, while still mounted on the large shaker, the outputs of the + and -12 Volt regulated power supplies were found to be slightly out of tolerance. Follow-on testing at another location could not duplicate this condition, nor could any logical circuit analysis account for a failure causing the observed deviation. It was concluded that induced fields from the shaker had caused the deviation. (Status -- closed)

D. Ready Light Flicker, FIAR-S-191-8036

During integrated systems testing at MMC Denver, it was observed that the ready light came on momentarily when system power was turned on. It was concluded that this was due to normal turn on transients and had no deleterious effect on system performance. (Status -- closed)

E. Vac-ion pump current, FIAR-S-191-8077

During integrated systems testing at MMC Denver it was reported that this output was of stepped spike nature instead of steady D.C. It was concluded that the observed output was normal for this type of device. (Status -- closed)

F. Recorded Data Anomalies FIAR's S-191-8078, 79, 80
S-191-8120

During integrated systems testing and FIV tests several reports were issued concerning spectrometer data outputs as read from recorded data. It has been established that none of these anomalies were associated with spectrometer performance. (Status -- closed)

CRITICAL ITEM SUMMARY

There are no Category I Failure Modes in the IR Spectrometer systems produced by Block Engineering, Inc. for the S-191 Experiment.

There are no Category II Failure Modes in the IR Spectrometer systems produced by Block Engineering, Inc., for the S-191 Experiment.

MINOR PROBLEMS AND CORRECTIVE ACTIONS

Component Failures

- A. Integrating Sphere and Cap., Optronic Labs.,
Block Engineering Part No. 631433

Reference FIAR's 5325, 5338, and 5343

Description of Problem:

1. Integrating sphere cap was mounted on calibration wheel by epoxy bond around edge of cap. During high level vibration testing the cap broke loose from wheel.
2. During docking shock test the integrating sphere broke into several pieces.
3. A fix was installed providing complete support for the sphere by potting into a metal shell. During high level vibration in this configuration the integrating sphere cracked.

Failure Analysis and Corrective Action

1. The integrating sphere cap parted from its mounting beyond the epoxy bond, indicating cap material strength insufficient for unsupported mounting. A metal cover with rubber pad was added. Retesting showed no failure.
2. The integrating sphere mount was redesigned using a metal shell with silicon rubber pads between shell and a sphere for support. This configuration retested for vibration and shock with no failure.

Status: Closed

MINOR PROBLEMS AND CORRECTIVE ACTION

Component Failures

B. Pulse Code Modulation Encoder

EMR Model POA-B4050

Reference FIAR's 5301 and 5336

Description of Problem:

1. During preliminary calibration of the IR spectrometer system, the clock signal from the PCM encoder disappeared.
2. During manufacturing testing of Flight Hardware, it was detected that one side of differential data output line was nonconforming in phase and impedance.

Failure Analysis and Corrective Action:

1. Failure Analysis showed output driver on clock output damaged due to overstress. Evaluation of test setup showed possibility of potential between IR Spec. Chassis and test equipment. Procedures changed to assure bonding of all equipment during test.
2. Failure Analysis showed intermittent connection caused by fractured solder join on internal connector pin. Defective joint repaired, all other connections reinspected, equipment fully retested.

Status: Closed

MINOR PROBLEMS AND CORRECTIVE ACTIONS

Design Problems:

A. Gear Box Assembly, Block Engineering Part No. 950135

Reference FIAR: 5302 (FIAR 5342 referenced)

Description of Problem:

1. When exposed to thermal vacuum environment of acceptance test, the gear train ceased operation.

Failure Analysis and Corrective Action

1. Thermal analysis and retest indicated a temperature distribution within the assembly when operated in vacuum, leading to unequal thermal expansions, reducing gear clearance between drive motor gear and first reduction gear to zero, and the resultant binding stopping all motion.
2. Gear clearance was increased by approximately .0035 inch by reducing diameter of mounting shoulder of drive motor and shimming motor away from first reduction gear. Unit operated satisfactorily on many subsequent retests.

Status: Closed

Design Problems

B. E.M.I. Non-conformance

Reference FIAR: 5305

Description of Problem:

1. When tested for Electro-Magnetic Interference, the IR spectrometer system exceeded specification requirements by a small amount on emission tests at several frequencies.

Failure Analysis and Corrective Action

Waiver request No. K-E-84 was approved as Waiver S-191-9 to accept the instrument in its existing configuration for EMI requirements.

Status: Closed

MINOR PROBLEMS AND CORRECTIVE ACTIONS

Design Problems

- C. External dimensions of IR Spectrometer Block
Engineering Part No. 950142

Reference FIAR: 5332

Description of Problem:

1. Several external package dimensions were found to be under the low limits specified. No interface dimensions were involved.

Failure Analysis and Corrective Action

1. These dimensions controlled by ICD MSC-01008. This ICD was changed by IRN 18, to show the affected dimensions as "envelope" or maximum only.

Status: Closed

Design Problems

- D. Excess Weight

Reference FIAR: 5333

Description of Problem:

1. Total weight of IR spectrometer exceeded the maximum allowed by the End Item Specification, although all ICD requirements for weight were met.

Failure Analysis and Corrective Actions

1. Waiver request K-E-88 approved as S-191-13 to allow this condition on flight and backup hardware.

Status: Closed

MINOR PROBLEMS AND CORRECTIVE ACTION

Design Problems

E. Calibration Lamp Current

Reference FIAR: 5334

Description of Problem:

1. During acceptance testing of serial No. 02 hardware while undergoing thermal cycle testing the calibration lamp current was reading under low limits.

Failure Analysis and Corrective Action

1. It was determined that circuit oscillations were causing a malfunction of the current regulator for this lamp. Circuit modifications were included by ECO's 2274 and 2275 which corrected this problem. The correction was verified by retest.

Status: Closed

Design Problems

F. Double Reset Pulse

Reference FIAR's: S-191-8075, S-191-8125

Description of Problem:

1. A reset pulse is generated once for each revolution of the Circular Variable Filter, which resets the ramp voltage to zero and establishes the wavelength transmission timing information. This pulse has shown random and intermittent doubling.

Failure Analysis and Corrective Action

1. The doubling of this reset pulse is caused by noise or ringing of the pulse waveform. Initially the discriminator threshold level was increased by changing the setting procedure #403073. This was found to be not fully effective so the circuit was modified to a "set-reset" circuit by ECO#2302 and 2303.

Status: Closed, verified by retest.

MINOR PROBLEMS AND CORRECTIVE ACTIONS

Manufacturing Problems

A. Qualification Instrument Sensitivity

Reference FIAR: 5328

Description of Problem:

1. The instrument, Serial No. .01 failed to meet NESR requirements on both short and long wavelength channels.

Failure Analysis and Corrective Actions

1. Both the short wavelength detector and the long wavelength detector used in the qualification hardware, as well as the dichroic element, were of less than specification in sensitivity, although in all other respects were flight quality. These were used due to procurement problems and schedule pressures. This condition was approved by waivers S-191-7 (K-E-58), S-191-10 (K-E-85), and S-191-11 (K-E-86).

Status: Closed

Manufacturing Problems

B. Connector condition and marking.

Reference FIAR: S-191-8023

Description of Problem:

1. Upon receipt of Flight Hardware Serial No. .02 at MMC Denver, a report was issued stating that connectors were contaminated, damaged, and not properly marked with "J" numbers.

Failure Analysis and Corrective Action

1. Final cleaning and inspection procedures were revised to insure against release of any contaminated items. The damaged connector was replaced at refurbishment. Since no contractual requirement existed to mark "J" numbers on hardware, direction was given to MMC Denver to add these numbers at receipt.

Status: Closed

Calibration

The calibration of the spectrometers produced for this program was carried out as a first step in Acceptance Testing for each unit. Calibration was carried out in accordance with Block Engineering Calibration Test Procedure B-S191-108008. The results of this calibration of the Flight Hardware are fully described in Calibration Test Report B-S191-404005. Some of the data from the test is reproduced here for reference and comparison against the performance requirements shown in the section entitled "Design Specifications".

Summary of Instrument Performance

DETECTOR	Si	Pbs	HgCdTe
Wavelength Coverage	.39→1.1μ	1.1→2.51μ	5.82→15.99μ
Resolution	115±15Å (.39→.73μ) 185±40Å (.68→1.4μ)	1.5±.2λ (1.34→2.5μ)	1.9±.2λ (5.82→11.4μ) 1.9±.2λ (8.30→15.99μ)
Wavelength Scale Accuracy	.0013μ (.39→.73μ) .0032μ (.68→1.1μ)	.0032μ (1.1→1.4μ) .0025μ (1.34→2.51μ)	.012μ (5.82→11.4μ) .015μ (8.30→15.99μ)
Spectral Scan Period	.953±.001 sec	.953±.001 sec	.953±.001 sec
Noise	5.5 mV	10.0 mV	7.2 mV
DC Offset	55 mV (Si#1) 30 mV (Si#2)	30 mV	200 mV (+HgCdTe) 206 mV (-HgCdTe)
Peak Spectral Response	$2.08 \times 10^3 \frac{\text{Volts}}{\text{w/cm}^2 \cdot \mu\text{-st}}$ (@ 7300Å)	$8.6 \times 10^2 \frac{\text{Volts}}{\text{w/(cm}^2 \cdot \mu\text{-st)}}$ (@ 2.0μ)	$4.45 \times 10^3 \frac{\text{Volts}}{\text{w/(cm}^2 \cdot \mu\text{-st)}}$ (@ 11.3μ)
NESR at Peak Response Wavelength	$2.6 \times 10^{-6} \frac{\text{Watts}}{\text{cm}^2 \cdot \mu\text{-st}}$ (@ 7300Å)	$1.20 \times 10^{-5} \frac{\text{Watts}}{\text{cm}^2 \cdot \mu\text{-st}}$ (@ 2.0μ)	$1.6 \times 10^{-6} \frac{\text{Watts}}{\text{cm}^2 \cdot \mu\text{-st}}$ (@ 11.3μ)
Areal Field of View	.085 ster	.079 ster	.057 ster
Angular Field of View (width x height)	21.0° x 20.8°	20.4° x 20.6°	21.9° x 21.4°
Center of 50% Contour (azim x elev.) [25% for HgCdTe]	+0.1° x +0.5°	+0.2° x +0.4°	-0.3° x +0.1°

Power Required: 92.4±1.4 watts

Cooldown Time: 19 minutes

TABLE IV

PRECEDING PAGE BLANK NOT FILMED

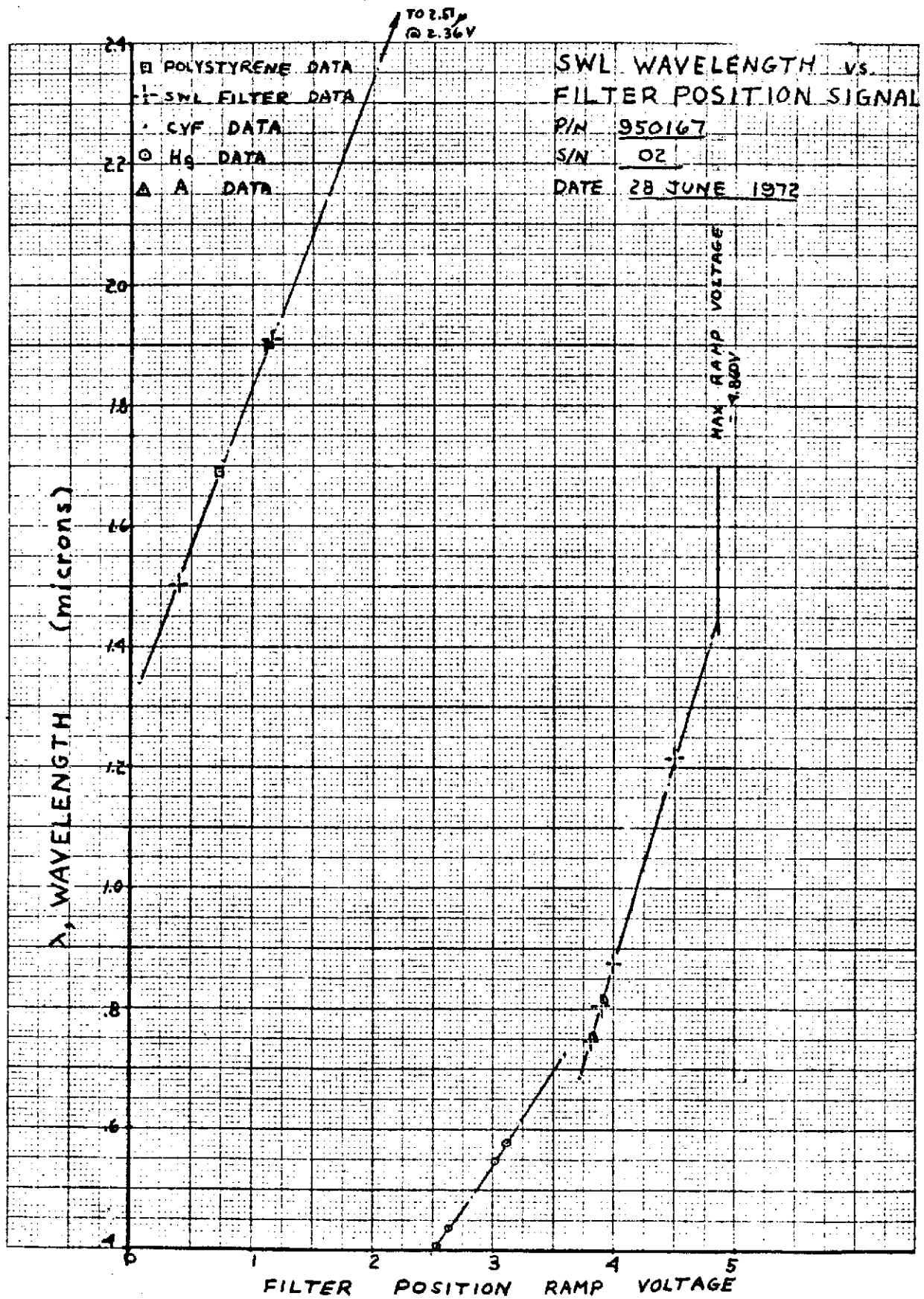


FIGURE 6

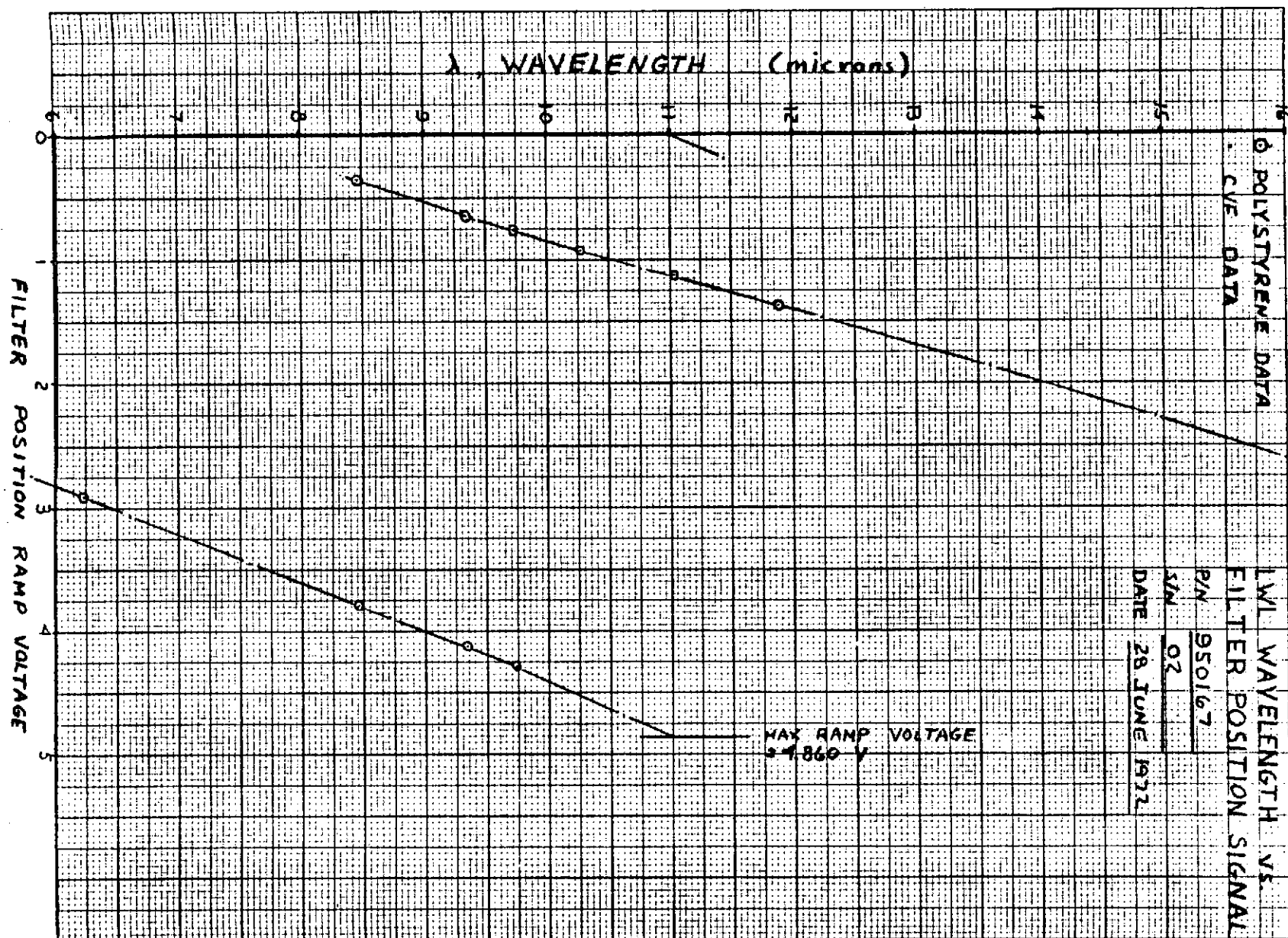


FIGURE 7

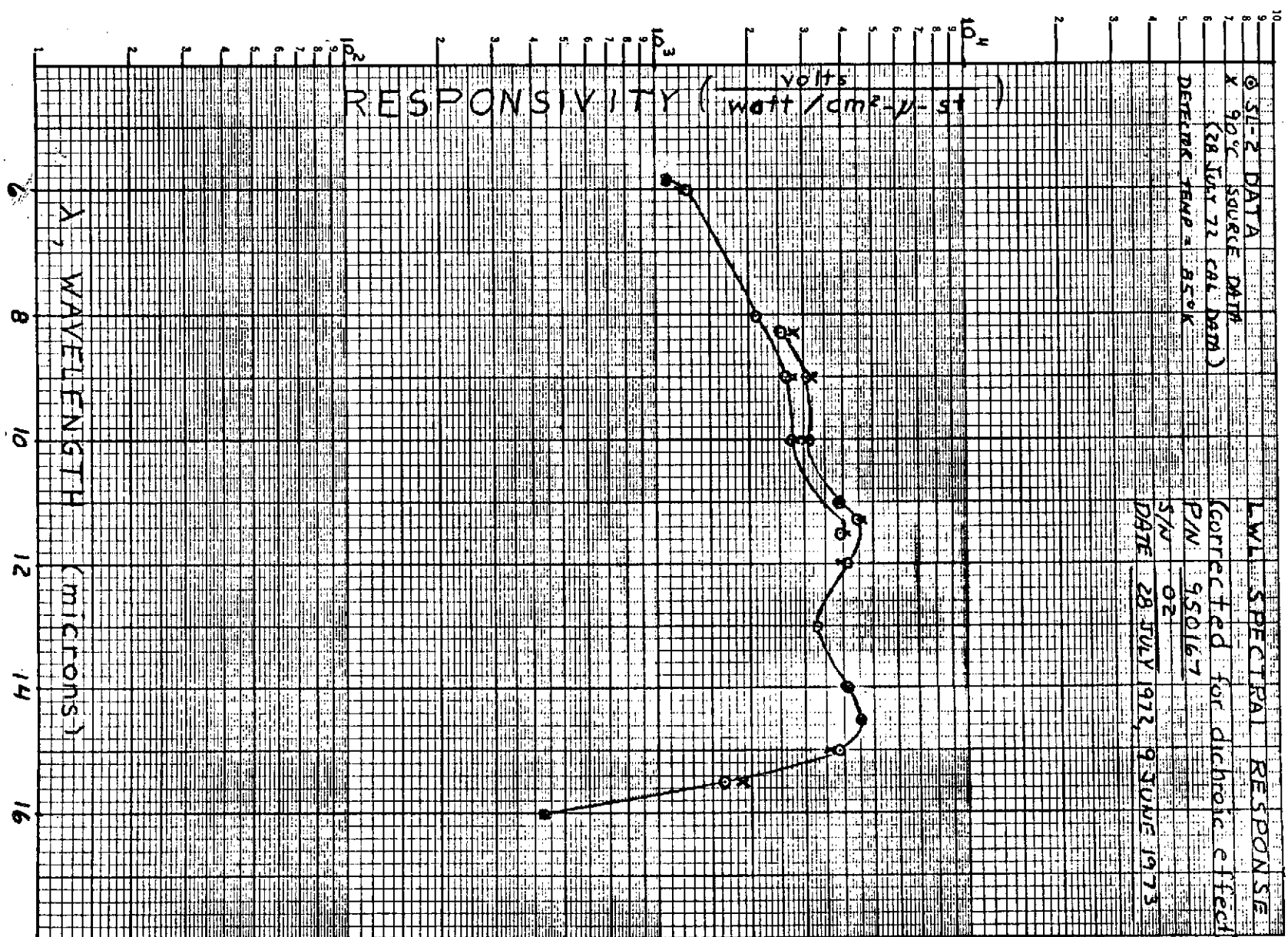


FIGURE 9

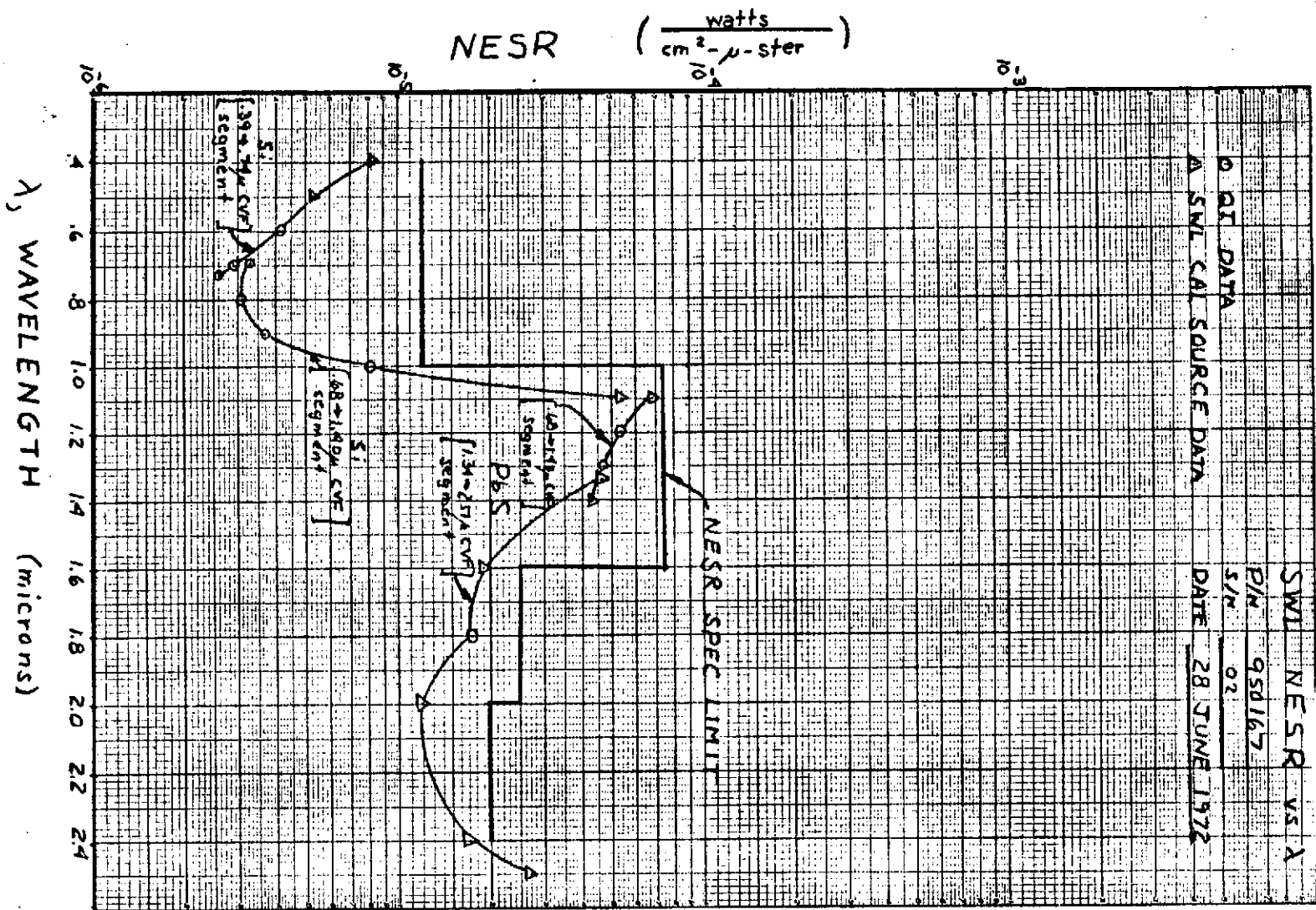


FIGURE 10

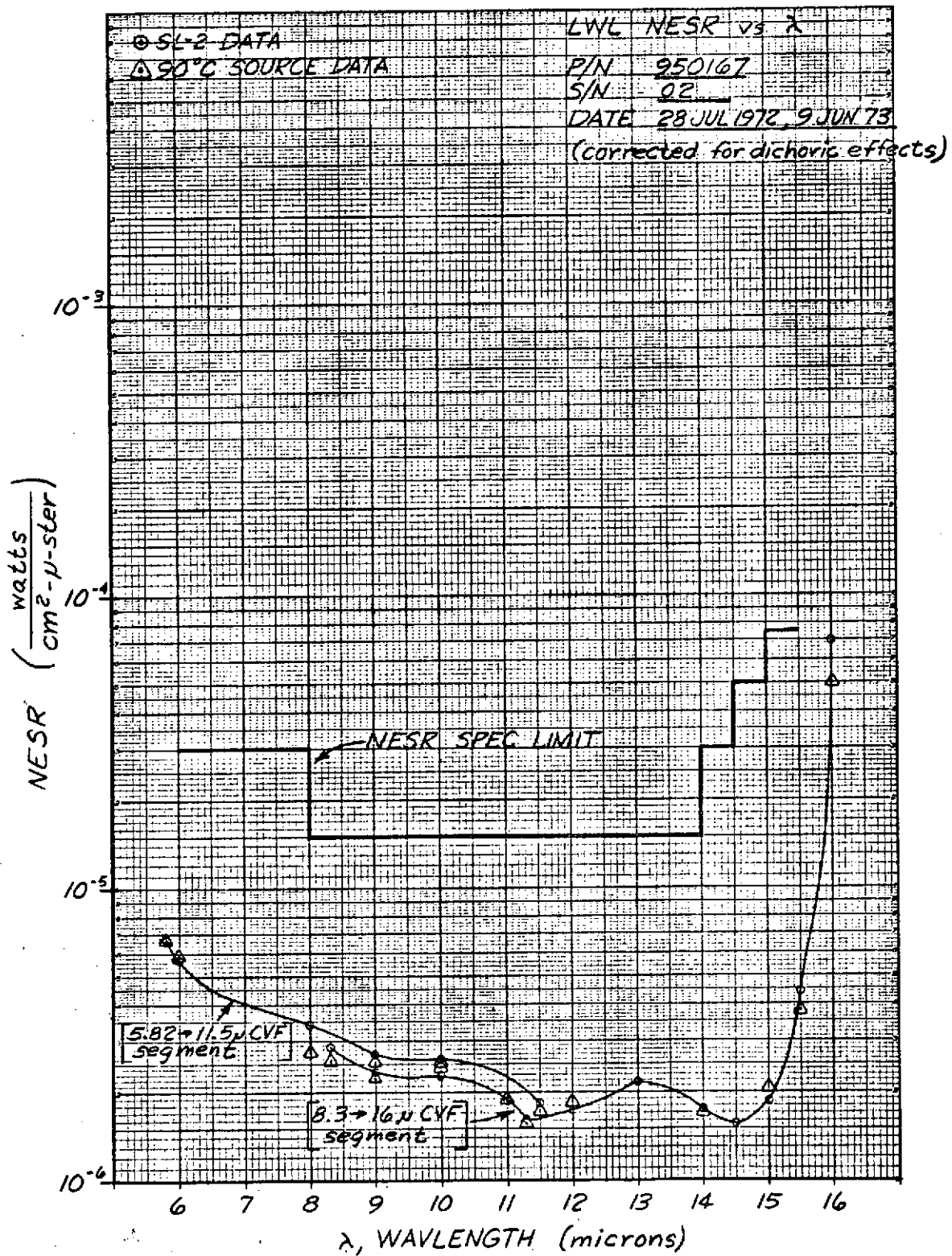


FIGURE 11

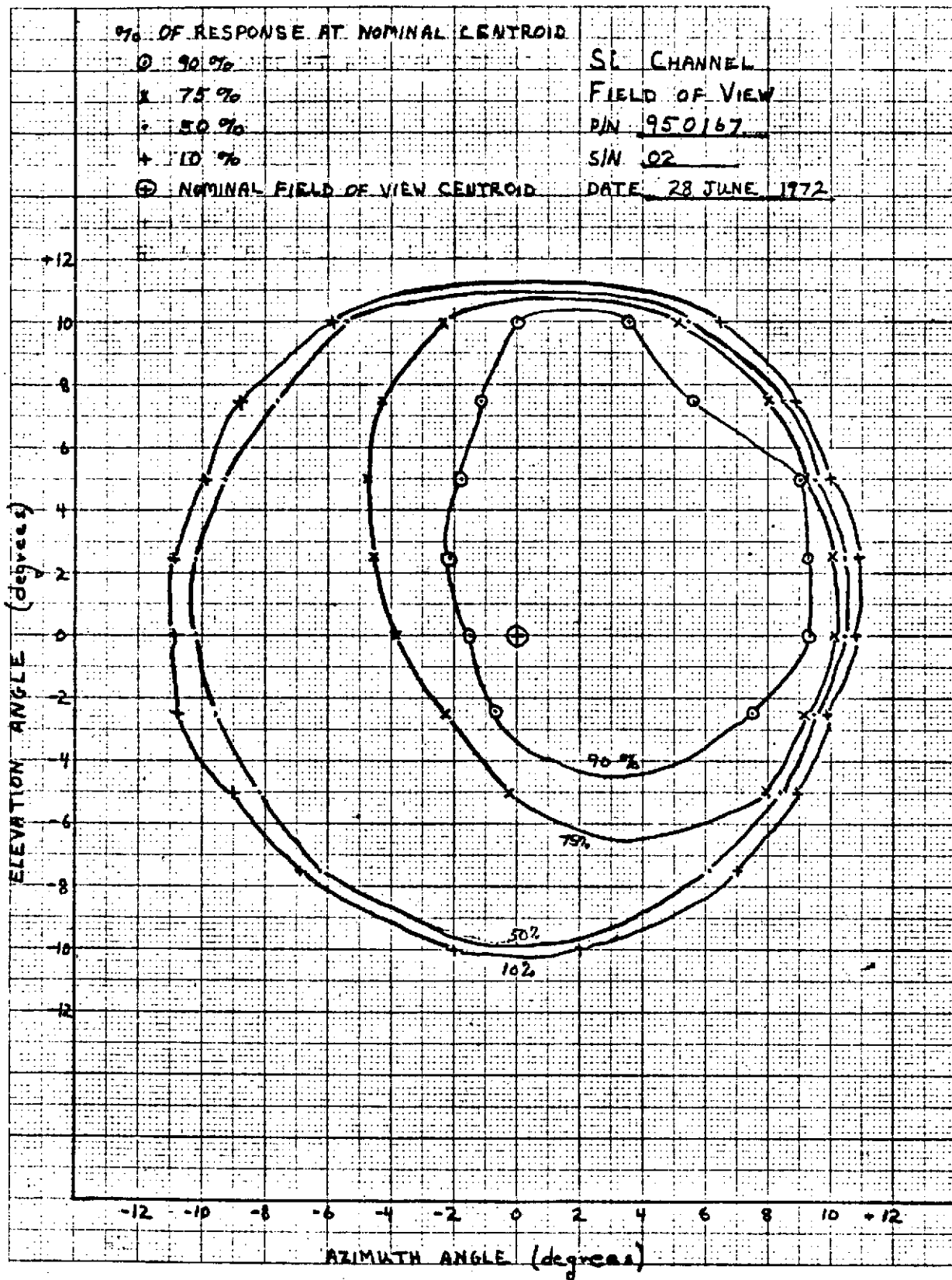


FIGURE 12

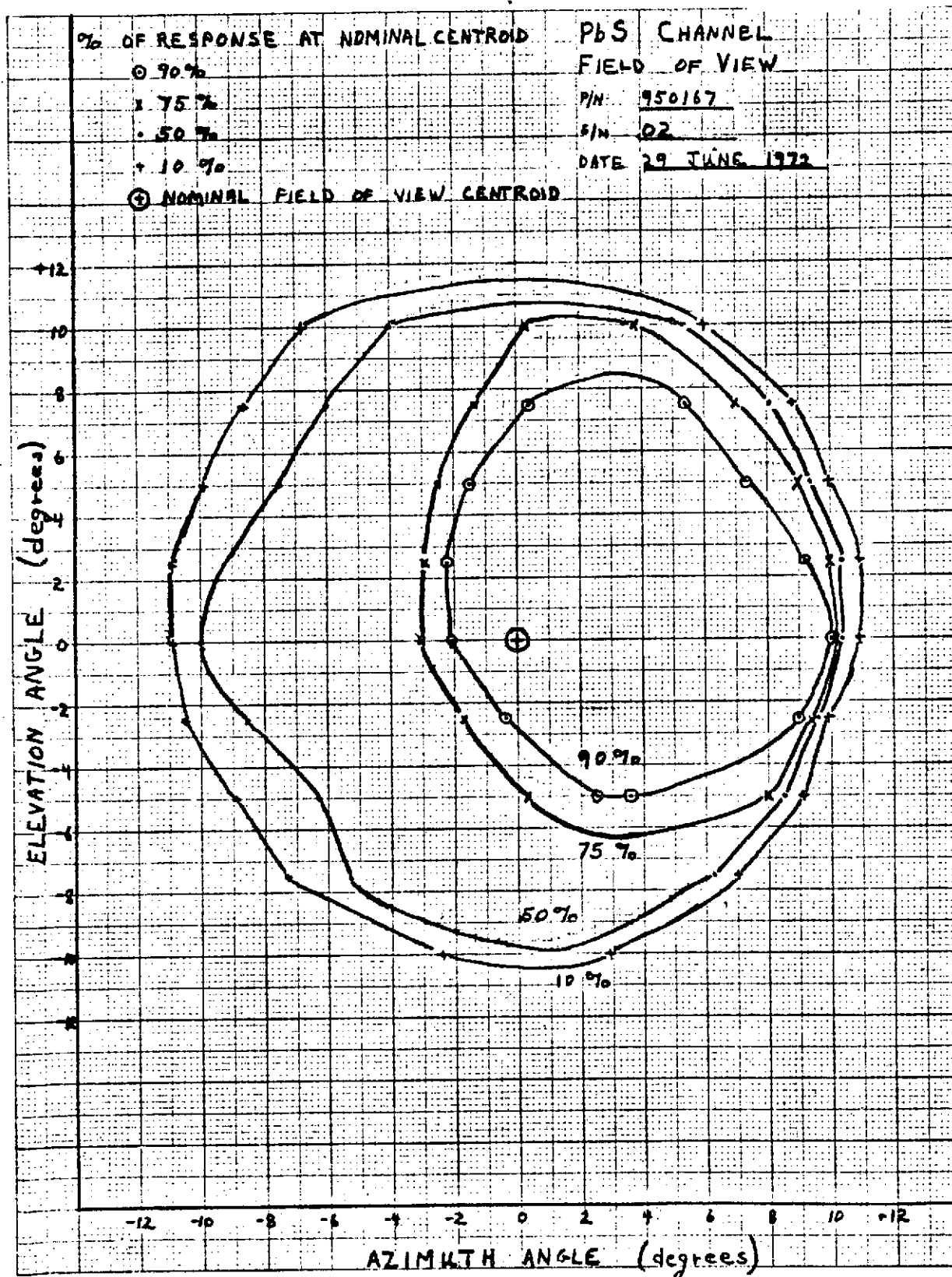


FIGURE 13

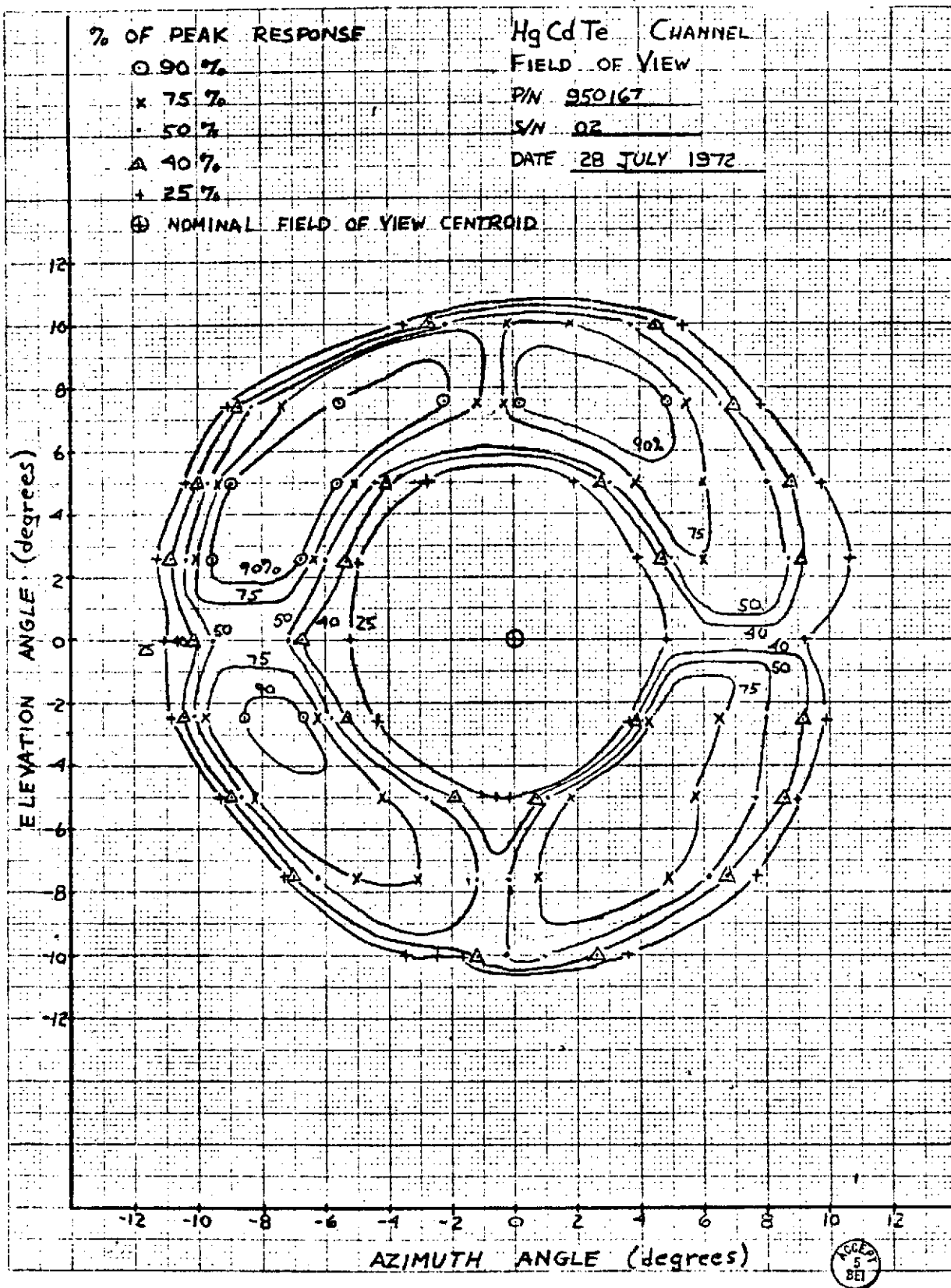


FIGURE 14

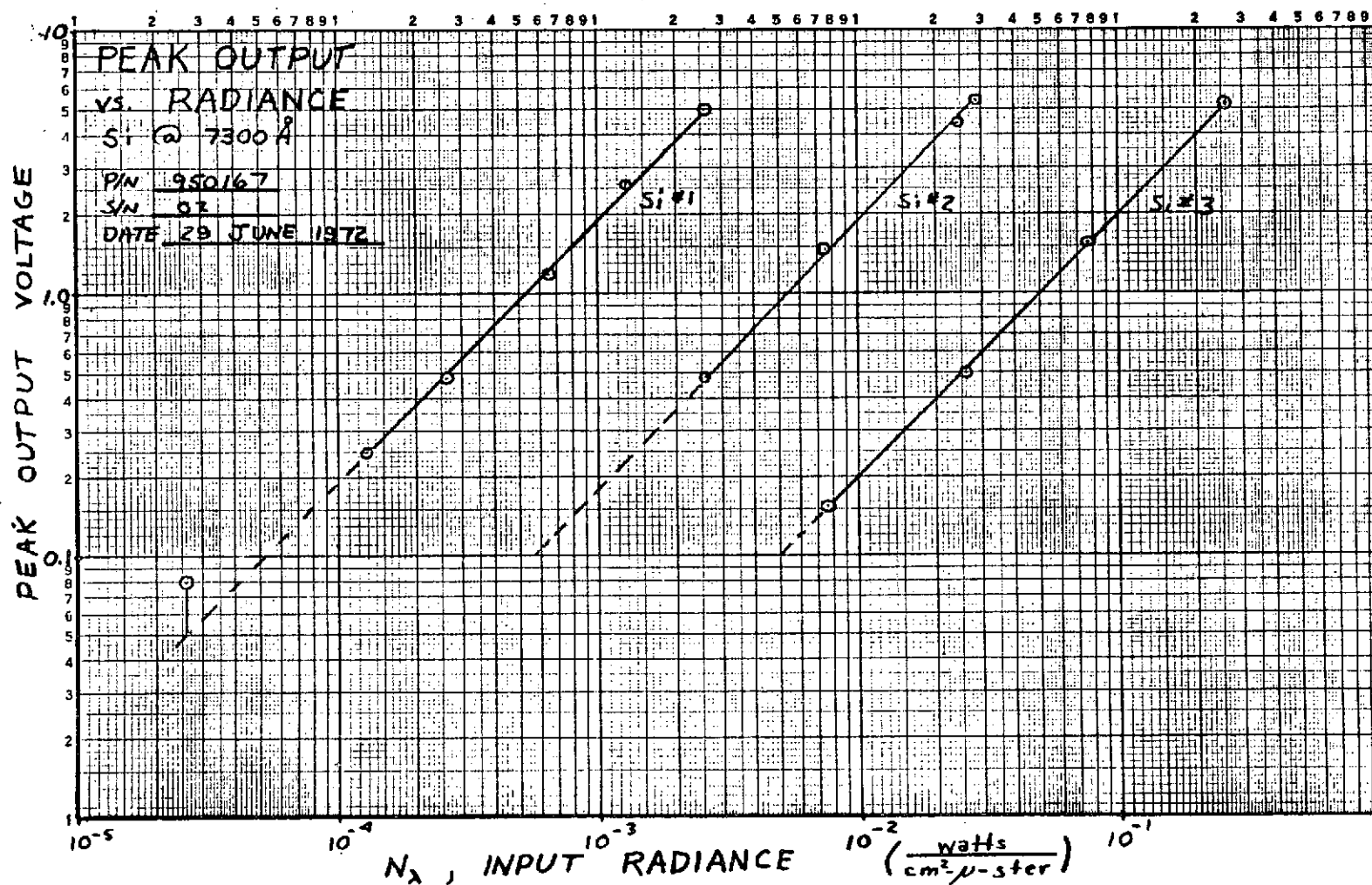


FIGURE 15

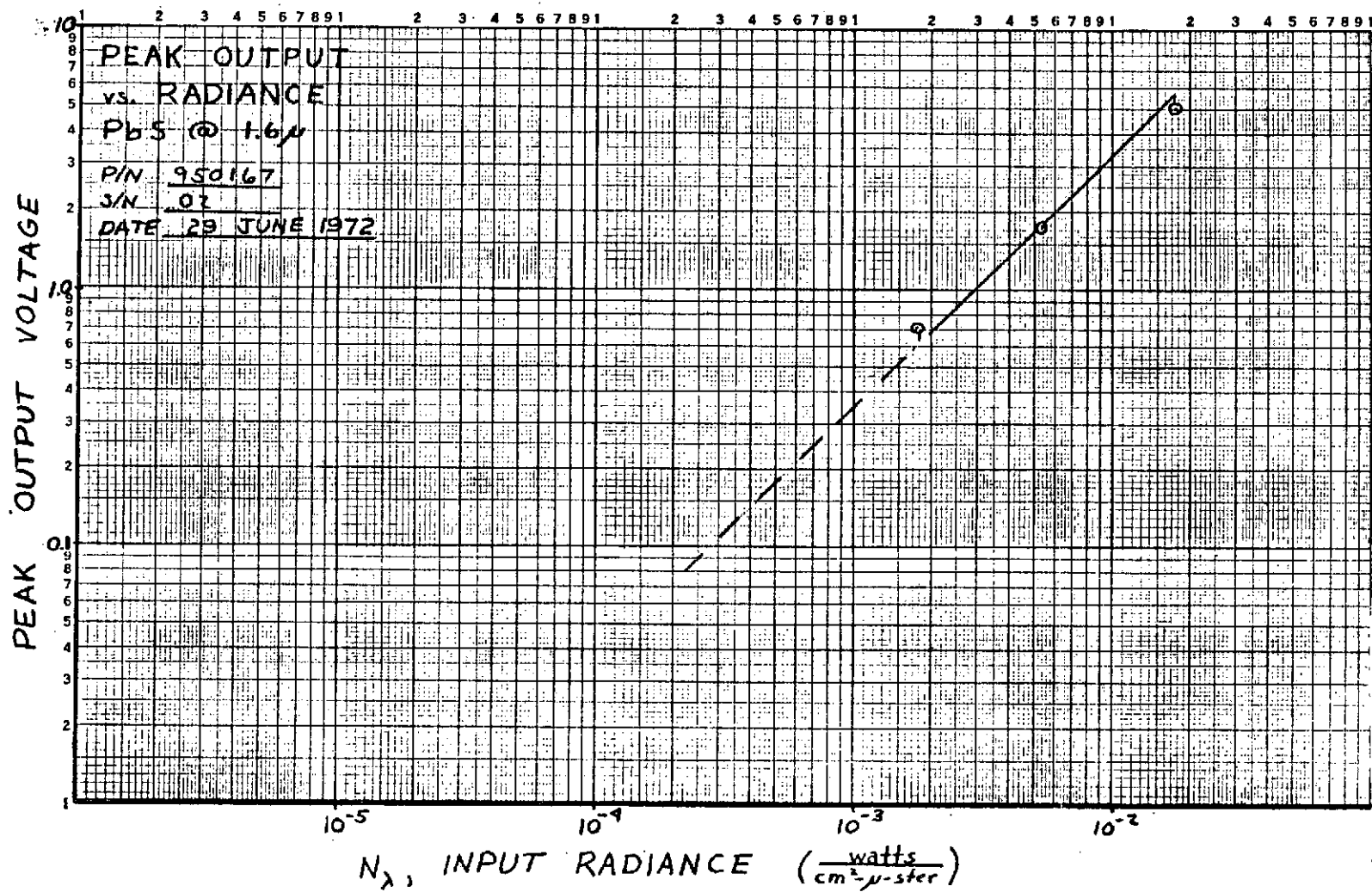


FIGURE 16

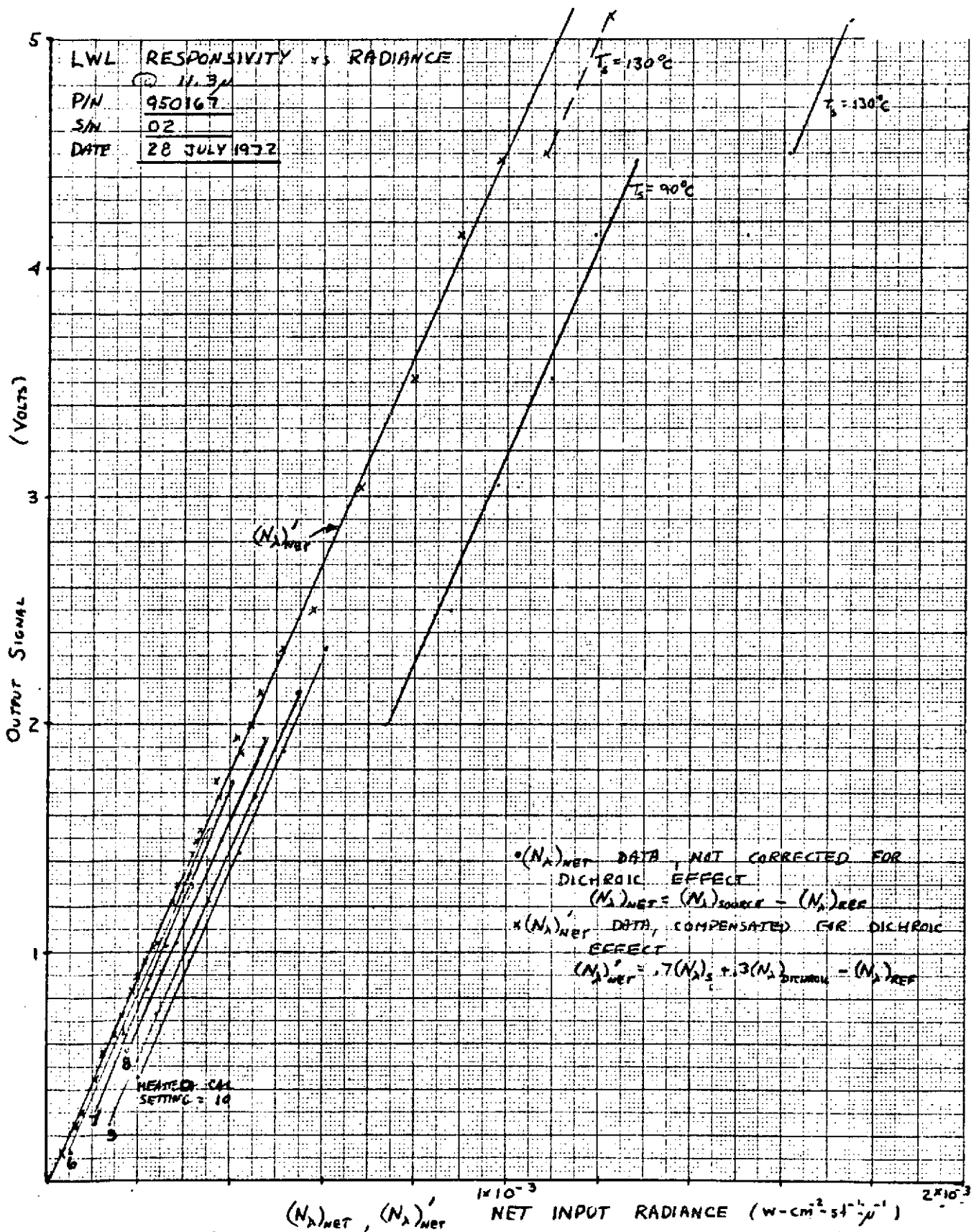


FIGURE 17

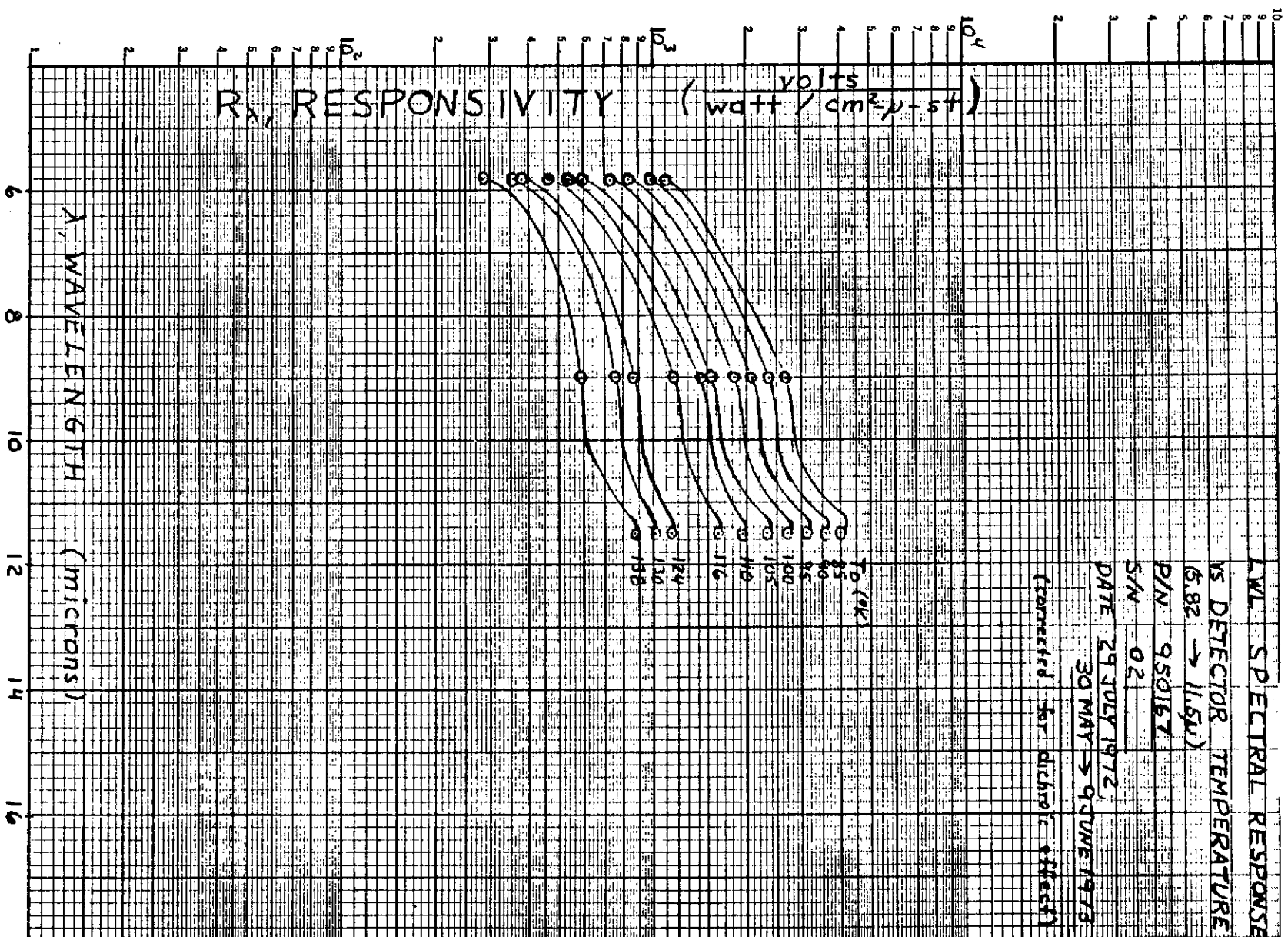


FIGURE 18

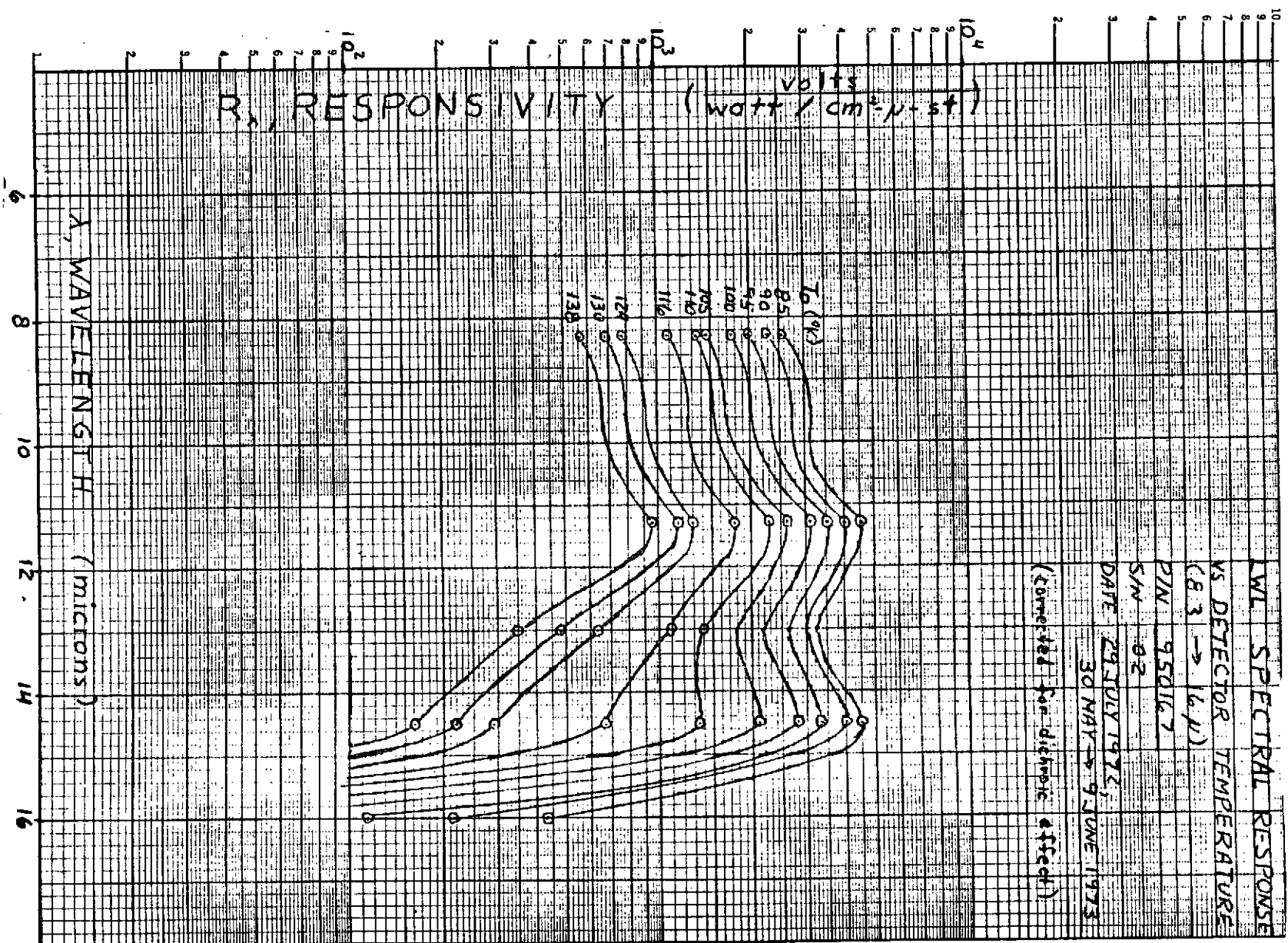


FIGURE 19

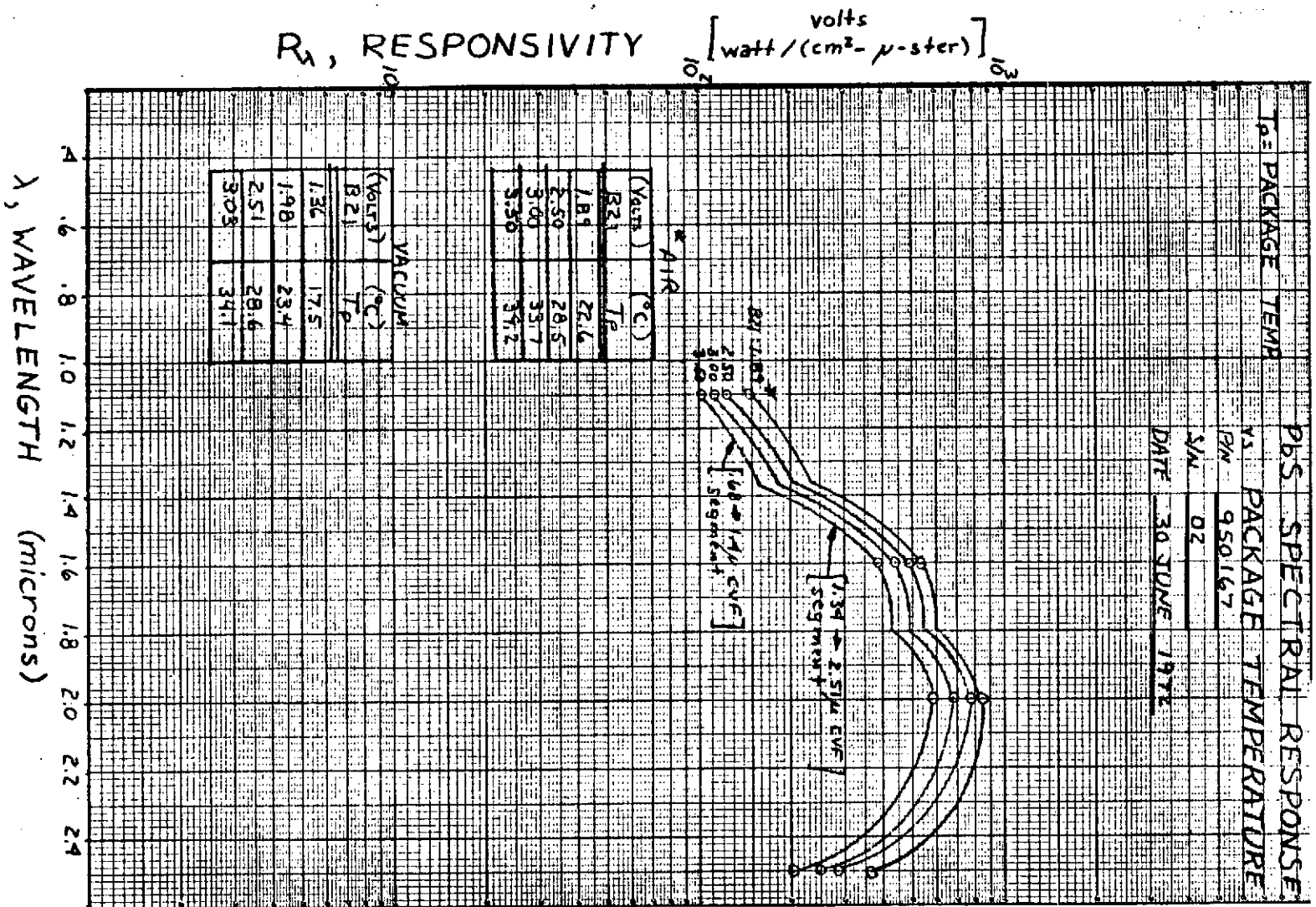


FIGURE 20

LWL SENSITIVITY AT PEAK RESPONSE WAVELENGTH

Thermal Reference Setting	T _{ref}	(N _λ)* _{ref}	Heated Cal Source Setting	T _{source}	(N _λ)* _{source}	λ _{peak}	(N _λ)* _{net}	V _p -V _{off-set}
5	10.1°C	7.32x10 ⁻⁴	6	36.8°C	10.84x10 ⁻⁴	11.3μ	3.52x10 ⁻⁴	1.53
6	17.5	8.21x10 ⁻⁴	↑	↑	↑	↑	2.63x10 ⁻⁴	1.04
7	25.4	9.16x10 ⁻⁴	↑	↑	↑	↑	1.68x10 ⁻⁴	.64
8	33.1	10.32x10 ⁻⁴	↓	↓	↓	↓	.52x10 ⁻⁴	.13
9	41.1	11.36x10 ⁻⁴	6	36.8°C	10.84x10 ⁻⁴	↑	-.52x10 ⁻⁴	noise
5	10.1°C	7.32x10 ⁻⁴	7	41.2	11.36x10 ⁻⁴	↑	4.04x10 ⁻⁴	1.75
6	17.5	8.21x10 ⁻⁴	↑	↑	↑	↑	3.15x10 ⁻⁴	1.30
7	25.4	9.16x10 ⁻⁴	↑	↑	↑	↑	2.20x10 ⁻⁴	.84
8	33.1	10.32x10 ⁻⁴	↓	↓	↓	↓	1.14x10 ⁻⁴	.32
9	41.1	11.36x10 ⁻⁴	7	41.2	11.36x10 ⁻⁴	↑	.00x10 ⁻⁴	noise
5	10.0°C	7.32x10 ⁻⁴	8	44.9	12.02x10 ⁻⁴	↑	4.70x10 ⁻⁴	1.94
6	17.5	8.21x10 ⁻⁴	↑	↑	↑	↑	3.81x10 ⁻⁴	1.49
7	25.4	9.16x10 ⁻⁴	↑	↑	↑	↑	2.86x10 ⁻⁴	1.04
8	33.1	10.32x10 ⁻⁴	↓	↓	↓	↓	1.70x10 ⁻⁴	.56
9	40.9	11.36x10 ⁻⁴	8	44.9	12.02x10 ⁻⁴	11.3μ	.66x10 ⁻⁴	noise

TABLE V

-70-

Thermal Reference Setting	T _{ref}	(N _λ) [*] _{ref}	Heated Cal Source Setting	T _{source}	(N _λ) [*] _{source}	λ _{peak}	(N _λ) [*] _{net}	V _p -V _{off}
5	10.0°C	7.32x10 ⁻⁴	9	48.9°C	12.72x10 ⁻⁴	11.3μ	5.40x10 ⁻⁴	2.15
6	17.5	8.21x10 ⁻⁴	↕	↕	↕	↕	4.51x10 ⁻⁴	1.68
7	25.4	9.16x10 ⁻⁴	↕	↕	↕	↕	3.56x10 ⁻⁴	1.22
8	32.9	10.32x10 ⁻⁴	↕	↕	↕	↕	2.40x10 ⁻⁴	.74
9	40.9	11.36x10 ⁻⁴	9	48.9°C	12.72x10 ⁻⁴	↕	1.36x10 ⁻⁴	.25
5	10.0°C	7.32x10 ⁻⁴	10	53.6	13.36x10 ⁻⁴	↕	6.04x10 ⁻⁴	2.33
6	17.5	8.21x10 ⁻⁴	↕	↕	↕	↕	5.15x10 ⁻⁴	1.88
7	25.4	9.16x10 ⁻⁴	↕	↕	↕	↕	4.20x10 ⁻⁴	1.43
8	32.9	10.32x10 ⁻⁴	↕	↕	↕	↕	3.04x10 ⁻⁴	.97
9	40.9	11.36x10 ⁻⁴	↕	↕	↕	↕	2.00x10 ⁻⁴	.45
10	48.5	12.72x10 ⁻⁴	10	53.6	13.36x10 ⁻⁴	↕	.64x10 ⁻⁴	noise
5	10.0	7.32x10 ⁻⁴	N/A	90°C	20.10x10 ⁻⁴	↕	12.78x10 ⁻⁴	4.47
6	17.5	8.21x10 ⁻⁴	↕	↕	↕	↕	11.89x10 ⁻⁴	4.15
7	25.4	9.16x10 ⁻⁴	↕	↕	↕	↕	10.94x10 ⁻⁴	3.52
8	32.9	10.32x10 ⁻⁴	↕	↕	↕	↕	9.78x10 ⁻⁴	3.05
9	40.9	11.36x10 ⁻⁴	↕	↕	↕	↕	8.74x10 ⁻⁴	2.50
10	48.5	12.72x10 ⁻⁴	N/A	90°C	20.10x10 ⁻⁴	11.3μ	7.38x10 ⁻⁴	2.00

IWL SENSITIVITY AT PEAK RESPONSE WAVELENGTH

Thermal Reference Setting	T _{ref}	(N _λ)* _{ref}	Heated Cal Source Setting	T _{source}	(N _λ)* _{source}	λ _{peak}	(N _λ)* _{net}	V _P -V _{off}
7	25.4	9.16x10 ⁻⁴	N/A	130°C	2.88x10 ⁻³	11.3μ	1.96x10 ⁻³	sat.
8	33.1	10.32x10 ⁻⁴	↕	↕	↕	↕	1.85x10 ⁻³	sat.
9	41.1	11.36x10 ⁻⁴	↕	↕	↕	↕	1.74x10 ⁻³	5.10
10	48.7	12.72x10 ⁻⁴	N/A	130°C	2.88x10 ⁻³	11.3μ	1.61x10 ⁻³	4.50
<div> <div>*N_λ in</div> <div> <div>watts</div> <div>cm²-μ-st</div> </div> </div>								

TABLE v (concluded)

Qualification Testing

The Qualification Testing program consisted of a component qualification test sequence for the cryogenic cooling engine, and the system qualification test sequence for the entire spectrometer system. Certain of the tests were conducted mounted on the optical bench which was a part of the Viewfinders Tracker System for maximum end use condition simulation.

The following summary shows successful completion of all qualification test requirements, with a chronological history of the test events listed.

S191 QUALIFICATION TEST PROGRAM SUMMARY

Component Qualification

Cryogenic cooler qualification

- a) environmental testing (B-S191-404001)
- b) thermal cycle testing (B-S191-404007)
- c) thermal vacuum testing (TP-SKY-019)

System Qualification Sequence

- 1 Qualification Testing (B-S191-108004)
 - 1.1 Shock Test -20g sawtooth (AETC 8436-1, para. 4.1)
 - 1.2 Functional Test (para. 3.11.2)
 - 1.3 Vibrational Test-6.6 grms (AETC 8436-1, para. 4.4)
 - 1.6 Functional Test (para. 3.11.2)
 - 1.7 EMI Tests (AETC 8436-1, para. 4.3)
 - 1.8 Functional Test (para. 3.11.2)
 - 1.9 Vibrational Test -11.3 grms - IS
(AETC 8436-1, para. 4.2.1)
 - 1.10 Functional Test (para. 3.11.2)
 - 1.11 Acceleration Test (MMC Q-003-P-03, Q-003-P-04)
 - 1.12 Functional Test (para. 3.11.2)
 - 1.13 Vehicle Dynamics Vibration Test
(MMC Q-003-P-03, Q-003-P-04)
 - 1.14 Functional Test (para. 3.11.2)
 - 1.15 Shock Test - 380g shock spectrum -
(MMC Q-003-P-03, Q-003-P-04)
 - 1.16 Functional Test (para. 3.11.2)

PRECEDING PAGE BLANK NOT FILMED

System Qualification Test Summary

Test	Date Completed	Status
Shock Test, 20g sawtooth 3 shocks/direction	17 July 1971	Successfully completed
Random Vibration Test, 6.6grms 4 min/axis - spectrometer module only	4 October 1971	Successfully completed
Low Temperature Storage, -40°F	22 October 1971	Successfully completed
EMI Tests, Methods CEO1, CEO2, CEO3, CEO4, CS01, CS02, CS06, RE02, RE03, of MIL-STD-461	21 October 1971	Successfully completed. Noncom- formances of CEO3 and CEO4 covered by waiver S-191-9
Vibration Test, 11.3grms 1 minute/axis - spectrometer module only	19 February 1972	Successfully completed
Acceleration Test, 1 min/axis	9 October 1971	Successfully completed
Vehicle Dynamics Vibration Test, 5-40Hz, 3 oct/min	11 October 1971	Successfully completed
Shock Test, 380g shock spectrum	19 February 1972	Successfully completed
Life Test	12 June 1972	Satisfied via hours accumulated during extensive testing to date.

TABLE VI

DETAILED QUALIFICATION TEST RESULTS

1. Date: 17 July 1971
Test: Basic design shock test
20g, 11ms sawtooth, 3 shocks/direction
(18 total)
Results: No discrepancy observed in ensuing functional test.
2. Date: 17 July 1971
Test: Random Vibration Test - spectrometer module
only 6.6g rms - 1 minute/axis
Results: No discrepancy observed in ensuing functional test.
3. Date: 19 July 1971
Test: Low temperature storage
-20°F for 4 hours
Results: No discrepancy observed in ensuing functional test.
4. Date: 20 July 1971 - 22 July 1971
Test: EMI test
Methods CE01, DE02, CE03, CE04, CS01, CS02,
CS06 (+50V spikes only), RE02, RS03 of
MIL-STD-461, MIL-STD-462.
Results: Nonconformances observed during CE03 and
CE04 exposures, waiver requested and granted
(S-191-9)
5. Date: 2 August 1971
Test: Random Vibration Test - spectrometer module
only 11.3g rms - 1 minute/axis
Results: Integrating sphere cap broken. Design for
mounting cap was changed for retest at later
date (FR 5325) Retest completed.
6. Date: 30 September 1971
Test: Low Temperature Storage -40°F for 4 hours.
Results: Cryogenic cooler failed to function
properly in ensuing functional test
(FR 5337) Retest completed.
7. Date: 4 October 1971
Test: Random vibration test
6.6g rms. - 3 minutes/axis - spectrometer
module
3.6g rms. - 4 minutes/axis - electronics
module
Results: No discrepancy observed in ensuing functional
test.

8. Date: 9 October 1971
Test: Acceleration Test at MMC
7 g's - flight axis (\pm X)
2.3g's - \pm Y axis
4.6g's - \pm Z axis, 1 minute/direction
Results: No discrepancy observed in ensuing functional test.
9. Date: 11 October 1971
Test: Vehicle dynamics vibration test at MMC
5 - 40Hz flight axis
5 - 20Hz other axis, 30 ct/min
Results: No discrepancy observed in ensuing functional test.
10. Date: 12 October 1971 - 13 October 1971
Test: Docking shock test at MMC
380g shock spectrum
Results: Integrating sphere broken (FR5338)
Design for mounting sphere was changed and retested.
Thermistor lead in dewar assembly opened (FR5339).
Vendor of dewar changed design of lead attachment for future use.
Retest completed.
11. Date: 21 October 1971
Test: EMI Test
CS06 (-50V spikes only).
Results: No discrepancy observed in ensuing functional test.
12. Date: 22 October 1971
Test: Low temperature storage
-40°F for 4 hours
Results: No discrepancy observed in ensuing functional test.
13. Date: 26 October 1971
Test: Random vibration test - spectrometer module only 11.3g rms - 1 minute/axis
Results: Particle of CVF found in gear train FR(5342, 5340). CVF breakage later determined to be due to discrepant CVF substrate which cracked during thermal cycling. Retest completed.

Acceptance Testing

Each hardware system produced under this contract was fully inspected and tested to an approved acceptance test procedure prior to shipment.

In addition to the Qualification hardware and Flight hardware acceptance tests which are summarized and detailed on the following pages, the IFTU was fully acceptance tested, the Helicopter Unit was acceptance tested, and all GSE units were acceptance tested. All of these systems met all acceptance test requirements prior to shipment.

S191 ACCEPTANCE TEST SUMMARY - FLIGHT AND QUALIFICATION HARDWARE

1. Calibration Testing (B-S191-108008)
2. Acceptance Testing (B-S191-108003)
 - 2.1 Inspection (Visual/Mechanical) (para. 4.1)
 - 2.2 Recording of Calibration Data (para. 4.2.2)
 - 2.3 Signal Output Verification (para. 4.2)
 - 2.4 Functional Test (para. 3.11.2)
 - 2.5 Vibration Test -3.6 grms (AETC 8436, para. 4.1)
 - 2.6 Functional Test (para. 3.11.2)
 - 2.7 Altitude (Thermal-Vacuum) Test (AETC 8436, para. 4.2)
 - 2.8 Functional Test (para. 3.11.2)
3. Modified Acceptance Testing (B-S191-108003)
 - 3.1 Inspection (Slit Measurement) (para. 4.1.7.2)
 - 3.2 Signal Output Verification (para. 4.2.5)

PRECEDING PAGE BLANK NOT FILMED

Acceptance Test Summary (Flight Hardware)

Test	Date Completed	Status
Calibration Test (B-S191-108008)	14 January 1972	Successfully completed
Visual/Mechanical Inspection	15 January 1972	Successfully completed
Signal Output Verification	15 January 1972	Successfully completed
Random Vibration Test, 3.6 grms 1 minute/axis	17 January 1972	Successfully completed
Thermal - Vacuum Test	24 January 1972	Successfully completed
Slit Measurement	25 January 1972	Successfully completed
Signal Output Verification	25 January 1972	Successfully completed

TABLE VII

S191 ACCEPTANCE TEST RESULTS - QUALIFICATION HARDWARE

Date: 23 June 1971 → 28 June 1971

Test: Calibration

Results: NESR out-of-spec due to defective dichroic.
Dichroic replaced at later date.
waivers requested and granted (S-191-7,
S-191-10, S-191-11).

Date: 1 July 1971

Test: Mechanical and electrical checkout.

Results: No anomalies observed.

Date: 2 July 1971

Test: Low level random vibration - operating
3.6g rms 1 minute/axis

Results: No discrepancy observed during test or in
subsequent functional test.

Date: 2 July 1971

Test: Thermal Vacuum Test
100 hrs. in vacuum at 120° F → 50°F.

Results: Gear train seized. End play in main shaft was
increased. (FR 5302)

Date: 6 July 1971

Test: Thermal Vacuum Test

Results: Gear train seized. Gear clearance was in-
creased for subsequent testing. Cooler malfunctioned
and was replaced. (FR 5302, 5303)

Date: 11 July 1971 → 15 July 1971

Test: Thermal vacuum test

Results: Cooler malfunctioned in functional subsequent
to test and was later replaced. Retest required.
(FR 5304)

Date: 16 July 1971

Test: Temperature exposure - electronics module
20°F 120°F 8 hr. exposure.

Results: No discrepancy observed in ensuing functional
test.

Date: 29 July 1971 → 2 August 1971

Test: Thermal vacuum test

Results: Cooler malfunctioned in functional subsequent
to test. Retest required. (FR 5324)

S191 ACCEPTANCE TEST RESULTS - FLIGHT HARDWARE

Date: 8 August 1971 - 9 August 1971

Test: Calibration

Results: No anomalies observed

Date: 10 August 1971 - 12 August 1971

Test: Mechanical and electrical checkout

Results: External dimensions and weight out of tolerance. (FR 5332, 5333)
ECD envelope dimensions were changed to agree with hardware (IRN 18 to MSC 01008). Waiver was requested and granted on weight (S-S191-13)

Date: 13 August 1971

Test: Temperature exposure - electronics module

Results: Cal lamp current was observed low in pre-test (and post-) functional. Hardware was corrected prior to shipment. Anomaly was not attributable to test exposure (FR 5334).

Date: 14 August 1971

Test: Low level random vibration - operating
3.6g rms 1 minute/axis

Results: +12 volt outputs read high in pre- and post-test functional. Out-of-tolerance condition was not repeatable and was attributed to magnetic field of test fixture. (FR 5335).

Date: 15 August 1971

Test: Post environmental inspection

Results: No anomalies observed

S191 ACCEPTANCE TEST RESULTS - REFURBISHED FLIGHT HARDWARE

Date: 13 January 1972 - 14 January 1972
Test: Calibration
Results: No anomalies observed

Date: 14 January 1972 - 15 January 1972
Test: Mechanical and electrical inspection
Results: No anomalies observed

Date: 17 January 1972
Test: Low level random vibration - operating
Results: No anomalies observed during test or subsequent functional.

Date: 18 January 1972 - 22 January 1972
Test: Thermal vacuum test
Results: No discrepancy observed during test or subsequent functional

Date: 24 January 1972
Test: Temperature exposure - electronics module
Results: No discrepancy observed.

Date: 25 January 1972
Test: Post environmental inspection
Results: No anomalies observed.

Post Launch Activities

Following launch of the Skylab workshop, problems developed with the electrical power generation systems. As a result of these problems power shortages were experienced and anticipated temperature levels were not maintained. Specifically, it was not initially possible to operate the heaters on the outer walls of the MDA, and the wall temperature which was originally specified as a minimum of 60°F, dropped to a temperature as low as 44°F.

This caused the entire spectrometer package to reach a temperature well below the minimum anticipated and specified. As a result of this previously unscheduled decrease in temperature, an existing anomaly in the cryogenic cooling engine came into play. It had been observed in various tests that if the cooler case temperature was below the specified minimum of 60°F at the time of start up, it would have difficulty in bringing the cold tip to the required operating temperature. The initial EREP checkout showed this to indeed be the case, and so the operating procedure was temporarily modified to allow for the turn on of spectrometer electronics for some period of time prior to cooler start so that the heat from the electronics would preheat the cooler case. This procedure was effectively utilized until additional power made it possible to operate the MDA wall heaters as originally planned.

When the returned data from the first manned mission was reviewed another anomalous condition appeared, relating to the filter position ramp output voltage. This is a linear ramp voltage which goes from zero to approximately 5 volts once for each revolution of the circular variable filter, and is used to determine the instantaneous bandpass of the spectral data. During the period when the spectrometer was operating at temperatures below the specified minimum, this ramp on a few occasions intermittently "reset" to zero at points other than the true zero point. When the instrument had stabilized at proper operating temperatures this condition virtually disappeared, and was not considered to be a condition which would significantly interfere with data analysis.

All data reviews in which Block Engineering participated led to the conclusion that the S-191 spectrometer was operating satisfactorily and required no corrective actions to complete its mission.

The cooler began to indicate degradation toward the end of the SL-4 mission as evidenced by audible noise. At the end of this mission, the cooler failed completely, at approximately 101% of its lifetime certification predicted by JSC/PPD.

PRECEDING PAGE BLANK NOT FILMED

APPENDIX A

PROCUREMENT SPECIFICATIONS

The Following Listed Specifications are included herewith
for reference:

<u>SPECIFICATION NO.</u>	<u>TITLE</u>
B-S191-8001201	"Circular Variable Filter"
B-S191-8001202	" PCM System, S-191"
B-S191-8001205	"General Provisions for Subcontractors"
B-S191-8001206	"Special Provisions for Subcontractors"
B-S191-8001210	"Two Color Detectors"
B-S191-8001213	"Quality-Reliability Requirements"
B-S191-8001216	"General Environmental Requirements"
B-S191-8001217	"Cryogenic Cooler"
B-S191-8001218	"HgCdTe Detectors"

~~PRECEDING PAGE BLANK NOT FILMED~~

REV.	DATE	APPROVED
A	10-22-70	ECO 1718
B	10-22-70	ECO 1725
C	10-23-70	ECO 1728
D	11-3-70	ECO-1734
E	11-4-70	ECO 1735
F	12-9-70	ECO 1748
G	3-15-71	ECO 2008

1. Obtain from "Optical Coating Laboratory Inc."
2. Chips not to exceed .01" max. into surface
3. Surface Quality: 80-50 scratch and dig only. (Substrate only)
4. Bandpass coating is to be on the same side of the assembly for single element segments and on the inside surface closest to the bandpass side (single element) for laminated segments.
5. The linearity of the transmission band vs. angle, when plotted on a curve, shall be within 3% of a straight line for transmissions at a point of constant radius.
6. Active area of interest to be between 1.25" R - 1.6"R inside, and 1.70"R - 1.95"R outside. Specifications will be met in these regions.

17mμ or less	.4μ	→	.75μ
32mμ or less	.7μ	→	1.4μ
1.7% nom	1.3μ	→	2.4μ
2% nom	6.2μ	→	12μ
1.6% nom	8μ	→	15.5μ

Up to 1.3μ
Up to 4μ
Up to $2.5 \times$ central wavelength
Up to 18μ

MP 111

9. Out of band transmission over the blocking region must be less than 0.10%.
10. Bonding materials will be as previously submitted and historically have been compatible with the optical system in a vacuum.
11. CVP will have a shelf life of one year when stored in an OCLI dessicated container as supplied.
12. OCLI will attempt on a "Best Effort" basis to maintain 0.002" maximum discontinuity for the bandpass surface, and 0.010" maximum discontinuity for the opposite surface; this will include substrate selection for uniform thickness.
OCLI will guarantee 0.005" maximum discontinuity on the bandpass surface and 0.015" maximum discontinuity on the opposite surface.
13. Step height between components of Segment B not to exceed .005" radial, measured at O.D.
14. The peak transmittance shall be equal to or greater than the following values:

<u>Peak Transmission</u>	<u>Wavelength</u>	<u>Segment</u>
15% —————	.4μ —→ .75μ —————	.4μ —→ .75μ
12% —————	.7μ —→ 1.4μ —————	.7μ —→ 1.4μ
15% —————	1.3μ —→ 1.5μ	} 1.3μ —→ 2.4μ
30% —————	1.5μ —→ 1.7μ	
40% —————	1.7μ —→ 2.3μ	
35% —————	2.3μ —→ 2.4μ	
40% —————	6.2μ —→ 12.0μ —————	6.2μ —→ 12.0μ
35% —————	8.0μ —→ 13.0μ	} 8.0μ —→ 15.5μ
30% —————	13.0μ —→ 14.0μ	
25% —————	14.0μ —→ 15.0μ	
25% —————	15.0μ —→ 15.25μ	
18% —————	15.25μ —→ 15.5μ	

REVISION	1	2	3	4	5	6	7	8	9	10										
SHEET	1	2	3	4	5	6	7	8	9	10										
DRAWN DATE	Block Engineering, Inc. 19 BLACKSTONE ST. CAMBRIDGE, MASS.										DWG. NO. B-S191- 8001201 &					SHEET <u>2</u> OF <u>3</u>				
CHECKED DATE																				
APPROVED DATE	CODE IDENT: 21351										TITLE: Circular Variable Filter Purchase Specification									
APPROVED DATE																				

single ended, 0 to +5V

no damage will result if
any test point is accidentally
and continuously shorted to
ground

0.0000V to 5.1175V nominal
representing input to the
selected PCM channel

better than +0.1% of full scale

See note 1

50 ohms maximum

no damage will result when output is accidentally and continuously shorted to ground.

signal ground and chassis will be isolated from each other by more than 10Megohms shunted with less than 0.1 μ F. Voltages up to +100V between signal ground and chassis shall cause no damage

110 VAC $\pm 20\%$, 60Hz $\pm 10\%$
180 watts maximum

Mounts in a standard 19 inch rack

Panel height: 7 inches max.
Unit Depth: 22 inches
Weight: 55 pounds maximum

Mounting slides furnished
No forced air cooling required

[illegible]

REV.	DATE	APPROVED
		

NOTE 2

Logically functional during power interruptions of up to 1ms shall mean that no loss of synchronization in the multiplexer or loss of clock output or data output shall occur. However, the analog-to-digital conversion accuracy need not be maintained.

[illegible]

NOTE: Data output may not change state within $\pm 0.12\mu\text{s}$ of trailing edge of any clock pulse.

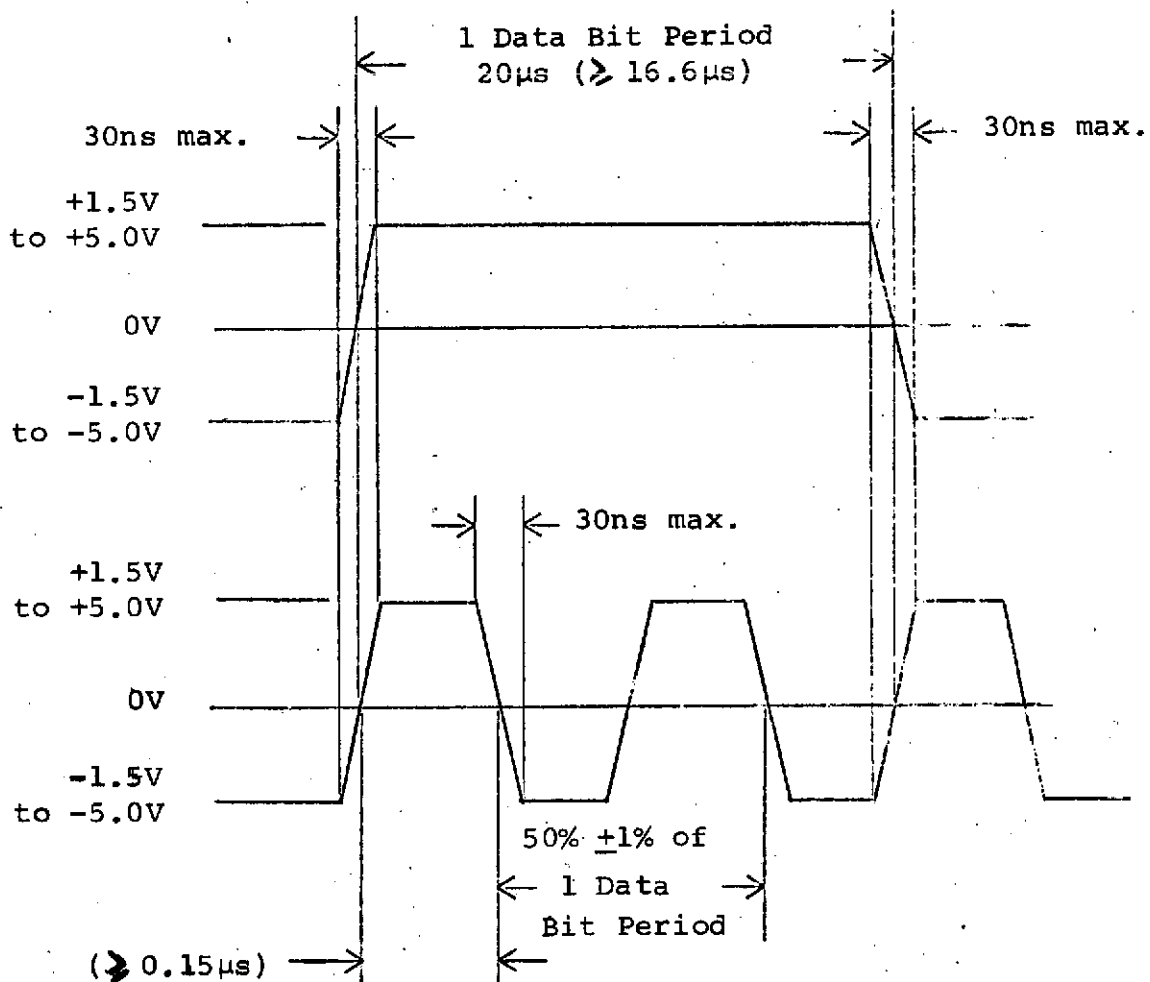


Fig. I

REVISION																			
SHEET	1	2	3	4	5	6	7	8	9	10									
DRAWN DATE	Block Engineering, Inc. 19 BLACKSTONE ST. CAMBRIDGE, MASS.										DWG. NO. B-S191- 78001202c					SHEET 13 OF 15			
CHECKED DATE																			
APPROVED DATE	CODE IDENT:										TITLE:								
APPROVED DATE	21351										PCM System S-191								

GENERAL PROVISIONS

Section A. Required Clauses - The provisions of the contract clauses set forth in the following paragraphs of the NASA Procurement Regulations (NASA PR) which are contained in the prime contract held by Block Engineering, Inc. are hereby incorporated into this subcontract (Purchase Order) by reference with the same force and effect as though herein set forth in full:

Clause No.	NASA PR Paragraph	Clause Title	Date of Clause
1	1.307-2	Priorities, Allocations, and Allotments	Sep 62
4	1.503	Covenant Against Contingent Fees	Feb 62
5	1.707-3(a)	Utilization of Small Business Concerns	Jul 62
8	1.805-3(a)	Utilization of Concerns in Labor Surplus Areas	Apr 68
19	6.104-5	Buy American Act	Sep 61
21	7.103-1	Definitions	Sep 62
28	7.103-8	Assignment of Claims	Sep 62
31	7.103-13	Renegotiation	Sep 62
32	7.103-19	Officials Not to Benefit	Sep 62
33	7.103-53	Interest	Jan 63
34	7.104-4	Notice to the Government of Labor Disputes	Sep 62
42	7.104-40	Competition in Subcontracting	Sep 62
43	7.104-42	Audit & Records	Oct 69
63	7.205-50	Notice of Delay	Sep 62
66	7.302-3	Standards of Work	Sep 62
69	7.302-54	Debeted.	
70	7.302-55	Scientific and Technical Information Service	Oct 69
82	9.101-4	New Technology	May 66
85	9.103(b)	Authorization & Consent	Sep 62
87	9.105	Notice & Assistance Regarding Patent & Copyright Infringement	Nov 64
90	9.203-1	Rights in Data	Jun 69
100	12.203	Convict Labor	Sep 62
101	12.303-1	Contract Work Hours Standards Act - Overtime Compensation	Nov 64
102	12.605	Walsh-Healey Public Contracts Act	Sep 62
103	12.802-1	Equal Opportunity Clause	Nov 67
141	7.203-7(a)	Examination of Records	Oct 69

Clause No.	NASA PR Paragraph	Clause Title	Date of Clause
142.2	7.402-8(a)	Subcontracts	Aug 69
143	7.203-22	Insurance - Liability to Third Persons	Sep 62
146	7.204-12	Security Requirements	Sep 62
150	7.402-5	Inspection & Correction of Defects	Sep 62
161	*8.702(a)	Termination	Sep 62
163	8.708	Excusable Delays	Oct 69
165	9.108-1	Payment of Royalties	Sep 62
171	13.703	Government Property	Oct 69

* Clause 161 cannot be used alone but must be used in combination with Clause 163.

** Deleted.

NOTE: Addition General Provisions

6	1.707-3(b)	Small Business Subcontracting Program	Nov 65
9	Deleted.		
16	3.807-4	Contractor & Subcontractor Certified Cost or Pricing Data Clause	Oct 69
48	7.105-8(c)	Stop Work Order	Jun 65
124	1.302-52	Geographic Participation in the Aerospace Program	Jun 66
142.3***	7.402-8(b)	Subcontracts	Aug 69

*** Clause 142.3 cannot be used alone but must be used in combination with Clause 142.2.

SPECIAL PROVISIONS

1. Changes

Block Engineering may at any time by written notice signed by Block Engineering's Buyer or higher authority make changes or additions within the general scope of this order to the drawings, specifications, instructions and work. If any such change or addition varies the cost of or time required for performance, the provisions of this order will be equitably adjusted. Any claim by Seller for such adjustment must be asserted in writing within thirty (30) days after receipt of such notice; provided, however, that Block Engineering may at its discretion, consider any such claim regardless of when asserted. Pending any such adjustment, Seller will diligently proceed with the order as modified.

2. Subcontracts

Seller will not subcontract, without Block Engineering's prior written consent, for the design or procurement of the whole or any substantial portion of any item ordered hereunder.

3. Termination

Convenience:

The performance of work under this order may be terminated in whole, or from time to time in part by Block Engineering for its convenience in accordance with the provisions set forth in ASPR 8-706.

Default:

Block Engineering may terminate the whole or any part of this order in either of the following circumstances:

- (a) If Seller fails to deliver the supplies or to perform the services required by this order within the time specified herein, or any extension thereof granted by Block Engineering in writing; or
- (b) If Seller fails to perform any of the other provisions of this order, or so fails to make progress as to endanger performance of this order in accordance with its terms, and in either of these two circumstances does not cure such failure within a period of ten (10) days after receipt of notice from Block Engineering specifying such failure.

In the event of such termination, Block Engineering shall have the right to procure, on such terms and in such manner as it may deem appropriate, supplies or services similar to those terminated, and to recover from Seller the excess cost for such similar supplies or services; provided, however, Seller shall not be liable for such excess costs where the failure upon which the termination is based has arisen out of causes beyond the control of Seller and without the fault or negligence of Seller. Such causes shall be deemed to include, but not be limited to fires, floods, earthquakes, strikes and acts of the public enemy. The rights of Block Engineering provided in this clause shall be in addition to any other rights provided by law or this order.

4. Disputes

Pending any decision pursuant to a dispute arising under this Purchase Order, Seller agrees to proceed diligently with performance of this Purchase Order.

The rights and obligations of Block Engineering and Seller under this Purchase Order shall survive completion of, and final payment under, this Purchase Order.

5a. Warranty

Both at any time during the performance of this Purchase Order and during the specified life of the equipment, Block Engineering may require the Seller to remedy by correction or replacement any failure by the Seller to comply with the requirements of this Purchase Order.

In the event Block Engineering claims that supplies and services furnished or to be furnished under this order do not conform to the description contained in this order and Seller contests the Block Engineering claim, Seller shall proceed in accordance with Block Engineering instructions pending resolution of this dispute. In the event of resolution of the dispute in favor of Seller, the price of this order shall be equitably adjusted to compensate Seller for efforts expended in complying with Block Engineering instructions insofar as Block Engineering instructions impose burdens upon the Seller in addition to those imposed by this order prior to the issuance of Block Engineering instructions.

5b. Repairs

When any unit of the subject equipment is returned for repair, Seller shall not readjust internal controls provided they are within the specified range. Any alteration of the equipment which has obviously been made to achieve installation compatibility, e.g., corner trimmed, clearance increased, etc. shall not be reworked without written Block Engineering authorization/direction. With this single exception, repaired units shall conform to this specification and shall be flight worthy and comparable in reliability to new units.

5c. Accept - Reject Criteria

Failure of the unit(s) to perform within specified limits or to conform to the procurement specification and/or Seller's drawings in any detail shall be cause for rejection. Transient anomalies which result in out-of-tolerance performance shall constitute a failure regardless of the duration of the anomaly except as may be provided for EMI transients in the applicable EMI testing criteria. The need for adjustment, alignment, recalibration or other maintenance function during or after acceptance test or flight proof tests shall constitute a failure. Evidence of any mechanical failure, crack, breakage or deformation shall constitute a failure.

5d. Seller's Design Responsibility

The Seller shall be responsible for producing a design and equipment which will satisfy all requirements of this procurement specification in accordance with the terms and conditions of the Block Engineering Purchase Order. In the event the Seller's equipment, or any component thereof, fails to meet the requirements of this specification or the Purchase Order, Seller shall be responsible, unless otherwise directed by Block Engineering in writing, for all redesign, rework, retesting and other associated efforts required to make all equipment or components thereof, delivered or otherwise, comply with the requirements of this procurement specification and the Purchase Order and to verify said compliance.

6. Liquidated Damages

Deleted.

7. Patents and Copyrights

Seller agrees to hold the purchaser harmless from any and all liability, loss or expense arising from patent and copyright infringements, alleged or otherwise, made by the Seller in connection with the goods ordered herein.

8. Notice of Labor Disputes

Whenever the Seller has knowledge that any actual or potential labor dispute is delaying or threatens to delay the timely performance of this order, the Seller will immediately give telegraphic notice thereof, including all relevant information with respect thereto, to the Block Engineering, Inc.

9. Assignment

Seller shall not assign this order or any interest therein without Block Engineering consent. By accepting this order Seller agrees that, if required by Block Engineering prime contract, Block Engineering may assign this order and any subcontracts thereunder to the Government Agency concerned.

10. Data - Withholding of Payment

Pending delivery and acceptance of all data items required by this Purchase Order, Block Engineering may withhold payment of 10% of the Purchase Order value until all such data is delivered or deficiencies, if any, are corrected. This retention, if taken, will be made after 90% of the Purchase Order value is paid.

DATA FOR PURCHASE SPECIFICATION 80012100

1. Detectors to be in two color sandwich configuration.
2. Front detector to be .6mm x .6mm silicon (Si).
3. Rear detector to be .6mm x .6mm lead sulfide (PbS).
4. Detector to be packaged in modified TO-18 can.
5. Detectors to be sensitive over wavelength region
 $0.4\mu \leq \lambda \leq 2.4\mu$.
6. Silicon detector to be AR coated for a peak transmission
at 1.4μ .
7. Interelement capacitance to be less than 5pf.
8. Detector package to conform to Block Engineering, Inc.
drawing no. 622360. (Refer to P.O. for Applicable Revision)
9. Dynamic range of Si detector to exceed 10^4 (linear within 5%)

1. Sensitivity of packaged Si detector to be D^* (0.8μ , 1000 Hz, 1 Hz) $\geq 8 \times 10^{11}$ cm-Hz^{1/2}-watt⁻¹ for a back bias voltage of 10 Vdc at a nominal ambient temperature of 27°C.
2. Sensitivity of packaged PbS detector to be D^* (2.4μ , 1000 Hz, 1 Hz) $\geq 5 \times 10^{10}$ cm-Hz^{1/2}-watt⁻¹ for a bias voltage of 12 Vdc at a nominal ambient temperature of 27°C.
3. Resistance of the PbS detector to fall in the range $500 \text{ K}\Omega \leq R \leq 2 \text{ M}\Omega$.

MP 111

BLOCK ENGINEERING, INC.

Purchasing Specification

Contracting Agency: NASA

Contract No.: NAS 9-10975

Reference: S191

QUALITY CONTROL REQUIREMENTS


1.0 General

- 1.1 This document presents the level of Quality Assurance and Reliability effort required by subcontractors and suppliers to Block Engineering, Inc. for the above listed contract.
- 1.2 The level of effort required by subcontractors who are furnishing major subassemblies or complete modules is described in Section 2.
- 1.3 The level of effort required by suppliers of electronic, electrical, and electromechanical parts is described in Section 3.
- 1.4 This document specifies requirements in addition to any which may appear on a purchase order, but may be modified by specifically stated purchase order requirements which will take precedence.

2.0 Subcontractor Requirements

2.1 Quality System Requirements

- 2.1.1 The subcontractor will maintain, as a minimum, a Quality System conforming in all respects to Military Specification MIL-Q-9858A.
- 2.1.2 Objective evidence of the required system will be presented in the form of a Quality System Manual which will be submitted to Block Engineering, Inc. for approval.
- 2.1.3 The purchase order will govern whether Government Source Inspection may be required. Prospective subcontractors must be prepared to provide all required verification information for the Government Representative. The Government may also elect to perform in-process verification of system and product quality.

PREPARED BY: 	PROJECT APPROVAL:		CUSTOMER APPROVAL:
CONTROL NO.: B-S191-8001213	REVISION: 0	DATE: 9-30-70	PAGE 1 OF 7 PAGES:

BLOCK ENGINEERING, INC.

Purchasing Specification

Contracting Agency: NASA

Contract No.: NAS 9-10975

Reference: S191

2.1.4 A representative of Block Engineering, Inc. will perform acceptance evaluation at the subcontractor's plant prior to shipment. This in no way relieves the subcontractor of the necessity of performing his own inspection, and will consist of a review of the instrument and all related data, test reports, etc.

2.2 Reliability Requirements

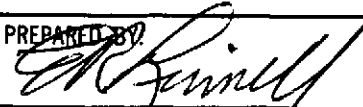
2.2.1 This equipment is essential for accomplishment of a secondary mission objective for a manned orbital mission experiment. The reliable operation of the equipment is therefore of great importance, and must be verified.

2.2.2 A target MTBF for all electronic equipment of 30,000 hours has been established. Although lower values will be considered, equipment meeting this requirement will be given first consideration.

2.2.3 A target MTBF for all electrical, mechanical, and electro-mechanical equipment of 3,000 hours has been established. Although lower values will be considered, equipment meeting this requirement will be given first consideration.

2.2.4 If the equipment is capable of demonstrating the required reliability on the basis of proven reliable operation of previously manufactured identical or demonstrably similar equipment, this information should be presented to the QA and Reliability Department of Block Engineering, Inc. for evaluation, and may be considered sufficient to satisfy the life requirements of this specification.

2.2.4.1 If the data as required above is not available, or is deemed insufficient or otherwise unsatisfactory, then the following action must be taken.

PREPARED BY: 	PROJECT APPROVAL:		CUSTOMER APPROVAL:
CONTROL NO.: B-S191-8001213	REVISION: 0	DATE: 9-30-70	PAGE 2 OF 7 PAGES:

BLOCK ENGINEERING, INC.


Purchasing Specification

Contracting Agency: NASA

Contract No.: NAS 9-10975

Reference: S191

- 2.3 A manufacturing flow chart must be submitted at least two weeks prior to the start of manufacture showing all assembly, inspection and test operation.
- 2.4 A log of all operating time will be maintained on the equipment from the time it reaches final assembly. This log will contain as a minimum the following information.
- a. Complete identification of the item.
 - b. The date and total time run.
 - c. The reason for operation (test, set-up, adjustment, etc.).
 - d. The results of the operation (in-spec., adjusted, failed test, etc.).
 - e. Any repairs performed.
 - f. The signature of the person who performed or witnessed the operation.
 - g. The completed log will be available for review at any time and will be shipped with the equipment.
- 2.5 Assembly of electrical circuits must comply with requirements of NASA document NHB5300.4(3A) May 1968.
- 2.6 Any test failures occurring during acceptance or qualification testing must be fully documented and definite correcting action must be defined and documented. Complete reports of all such actions must be submitted to Block Engineering, Inc.
- 2.7 The equipment covered by this specification shall be handled in such a manner during manufacturing that no dirt or contaminants of a size or location capable of causing a malfunction of the equipment under any circumstances will be present in the finished item. The outer surfaces will be free of visible dirt, soil, or hydrocarbons, as delivered. A statement as to the methods to be used for contamination control is required from the sub-contractor in his bid response.

PREPARED BY: 	PROJECT APPROVAL:		CUSTOMER APPROVAL:
CONTROL NO.: -S191-8001213	REVISION: 0	DATE: 9-30-70	PAGE 3 OF 7 PAGES:

BLOCK ENGINEERING, INC.

Purchasing Specification

Contracting Agency: NASA

Contract No.: NAS 9-10975

Reference: S191

- 2.8 The environmental stress requirements will be specified on the purchase order.
- 2.9 All items must be fully sealed units. Electrical connectors will meet the following requirements.
 - 2.9.1 Electrical circuits shall not be routed through adjacent pins of a connector if a short circuit between them could constitute a source of failure for the connected system.
 - 2.9.2 Cable connections shall be designed so that pin and socket connectors are properly used to prevent power from shorting to ground. They also shall be designed to protect personnel both when connected and disconnected, and, during the operations of connection and disconnection.
- 2.10 Each subcontractor shall identify each piece of equipment supplied with a unique serial number.
- 2.11 Each piece of supplied equipment shall be so designed that it will not be damaged by the application of power of reverse polarity.
- 2.12 Each piece of supplied equipment shall be so designed that any testing required during normal set-up and check-out can be accomplished at available test points with no necessity for disconnecting or probing connectors.
- 2.13 Each piece of supplied equipment shall be packaged for shipment in a manner which insures cleanliness and physical protection in shipment.
- 2.14 The following data, as a minimum, must be submitted with each instrument shipped.

PREPARED BY:

PROJECT APPROVAL:

CUSTOMER APPROVAL:

CONTROL NO.:
B-S191-8001213

REVISION:

0

DATE:

9-30-70

PAGE 4 OF 7 PAGES:

BLOCK ENGINEERING, INC.

Purchasing Specification

Contracting Agency: NASA

Contract No.: NAS 9-10975

Reference: S191


- 2.14.1 Copies of all screening data on all EEE parts used in assembly.
- 2.14.2 Complete detailed drawings and parts lists.
- 2.14.3 Complete and comprehensive acceptance test data showing characteristics checked, specification limits and observed data.
- 2.14.4 Completed equipment logs as required in paragraph 2.4 this spec.
- 2.14.5 All failure reports, failure analysis reports, and corrective action reports.
- 2.14.6 An MTBF on the completed instrument, verifying conformance to the requirements of paragraph 2.2.2 or 2.2.3 of this spec.
- 2.14.7 On orders requiring Government Source Inspection, evidence that such inspection has been accomplished.
- 2.14.8 Any other data required by the Purchase Order or additional referenced procurement documents.

3.0 EEE Parts Requirements

3.1 Order of preference of selection.

3.1.1 Wherever possible parts will be chosen which are qualified to an established reliability military specification and will be procured from a vendor listed on the Qualified Producers List for that item.

3.1.1.1 The listing on the QPL will be satisfactory evidence that the vendor maintains an effective Quality Control System.

PREPARED BY: 	PROJECT APPROVAL:		CUSTOMER APPROVAL:
CONTROL NO.: -S191-8001213	REVISION: 0	DATE: 9-30-70	PAGE 5 OF 7 PAGES:

BLOCK ENGINEERING, INC.

Purchasing Specification

Contracting Agency: NASA

Contract No.: NAS 9-10975

Reference: S191

3.1.1.2 Parts supplied against an established reliability specification must be accompanied by a summary of Group A and B testing required by that specification, which will include as a minimum:


- a. The type of part being tested
- b. The tests performed
- c. The number of parts tested
- d. The number of parts failing each test
- e. Where sample testing is used the lot size, sample size, and accept reject numbers must be shown
- f. Disposition of lot
- g. A reference number allowing traceability of the received parts to the summary report

3.1.1.3 Each shipment must also be accompanied by a completed Certificate of Compliance, and Block form QA870 must be used.

3.1.2 Where a satisfactory part can not be obtained from an established reliability specification then the next preference is a part which is supplied against a NASA part number, or a NASA contractor NASA approved part number.

3.1.2.1 Satisfactory evidence that the supplier maintains a quality control system equal in all respects to the requirements of MIL-Q-9858A must be furnished to Block Engineering, Inc. if such a requirement is not already contained in the specification.

3.1.2.2 Any such specifications considered for use must contain provisions for screening of the part. Block Engineering, Inc. will evaluate the screening procedure in line with contractual requirements.

PREPARED BY: 	PROJECT APPROVAL:		CUSTOMER APPROVAL:
CONTROL NO.: B-S191-8001213	REVISION: 0	DATE: 9-30-70	PAGE 6 OF 7 PAGES:

BLOCK ENGINEERING, INC.

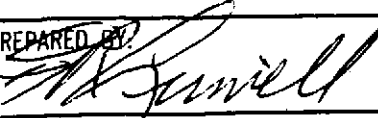
Purchasing Specification

Contracting Agency: NASA

Contract No.: NAS 9-10975

Reference: S191

- 3.1.2.3 Data to be delivered with these parts will be specified in the specification utilized or on the purchase order, and will in any case be at least equivalent to that required by paragraphs 3.1.1.2 and 3.1.1.3 of this specification.
- 3.1.3 Where a part meeting the requirements of paragraph 3.1.1 or 3.1.2 of this specification cannot be procured, then the following procedure will be followed.
- 3.1.3.1 A standard MIL-SPEC or equivalent quality commercial part will be selected which will meet the technical requirements of the application.
- 3.1.3.2 The part will be procured from a QPL or recognized quality commercial source. He will furnish a Certificate of Compliance using Block Engineering, Inc. form QA870.
- 3.1.3.3 Upon receipt, the part will be subjected to a screening program developed by Block Engineering, Inc. Parts failing this screening test will not be rejectable to the supplier, but will be immediately and individually identified as screening rejects and removed from any possibility of use in manufacturing.
- 3.1.4 All parts successfully meeting the requirements of paragraph 3.1.1, 3.1.2 or 3.1.3 will be marked with a diagonal white stripe which will not obscure designation marking but will identify as an acceptable part for this program. It will then be placed in secure stores until needed for manufacture.

REPAIRED BY: 	PROJECT APPROVAL:		CUSTOMER APPROVAL:
CONTROL NO.: -S191-8001213	REVISION: 0	DATE: 9-30-70	PAGE 7 OF 7 PAGES:

1.0 GENERAL REQUIREMENTS

This document describes the required configuration and performance characteristics of a closed cycle cryogenic cooler to be used in the Infrared Spectrometer, Experiment S191 of the Earth Resources Experiment Package, being developed by Block Engineering, Inc. under NASA Contract NAS 9-10975. The system is for use in manned space flight. Materials, manufacturing, and workmanship of highest quality standards are essential to astronaut safety. If you are able to supply the desired items with a quality which is higher than that of the items specified or proposed, you are requested to bring this fact to the immediate attention of the purchaser.

This document also specifies Quality Assurance, Reliability, and documentation requirements.

All coolers manufactured to the requirements specified herein shall be identical in configuration, performance, and fabrication procedure.

1.1 APPLICABLE DOCUMENTS

The following documents of the exact issue and date shown form a part of this procurement specification to the extent specified herein:

MIL-A-9067C

Adhesive Bonding, Process and Inspection
Requirements for (dated 3-16-61)

MIL-B-7883B

Brazing of Steels, Copper, Copper Alloys,
Nickel Alloys, Aluminum, and Aluminum Alloys
(dated 2-20-68)

MIL-C-3965D with Supplement 1, dated 3-4-68 and
Amendment 1, dated 10-29-68

Capacitors, Fixed, Electrolytic (Non-solid
Electrolyte), Tantalum, General Specification
for (dated 3-4-68)

MIL-I-6866B with Amendment 1, dated 8-10-64
Inspection, Penetrant, Method of (dated 2-26-64)

MIL-I-6868C with Amendment 1, dated 2-17-67
Inspection Process, Magnetic Particle
(dated 2-2-65)

MIL-Q-9858A

MIL-W-6858C
Welding, Resistance: Aluminum, Magnesium,
Non-hardening Steels or Alloys, Nickel Alloys,
Heat Resisting Alloys, and Titanium Alloys; Spot
and Seam (dated 10-20-64)

MIL-W-8604 with Amendment 1, dated 10-8-69
Welding of Aluminum Alloys, Process of (dated 6-5-53)

MIL-W-8611A
Welding, Metal Arc and Gas, Steels, and Corrosion
and Heat Resistant Alloys, Process for (dated 7-24-57)

MIL-STD-453 with Change Notice 1, dated 9-4-63
Inspection, Radiographic (dated 10-29-62)

MIL-STD-810B (USAF)
Environmental Test Methods (dated 6-15-67)

MIL-HDBK-5A
Metallic Materials and Elements for Aerospace
Vehicle Structures (dated 2-8-66)

MIL-STD-889
Metals, Definition of Dissimilar (dated 9-25-69)

MSC-D-NA-0002
Procedures and Requirements for the Flammability and
Off-gassing Evaluation of Manned Spacecraft Nonmetallic
Materials (dated 7-1968)

MSC-KA-D-68-1 (Revision B, 1-27-70)
AAP Experiment General Hardware Requirements

MSC-Spec-C-8 with Amendment 1, dated 1-5-67
Spacecraft on-board Equipment Cleanliness,
Specification for (dated 9-1966)

MSCM 5320

Management Manual - Parts Reliability
Requirements (dated 10-1969)

NHB-5300.4 (3a)

Requirements for Soldered Electrical
Connections (dated 5-1968)

BEI 80012090

Appendix A, Applicability of MSC-KT-D-68-1
to cryogenic cooler S-191, dated (10-20-70)

In the event of conflict with proprietary CTi processes or procedures, CTi specifications will take precedence, subject to NASA review and approval on an individual basis.

2.0 TECHNICAL REQUIREMENTS

2.1 POWER

The cryogenic cooler will be powered from the spacecraft 28 Vdc nominal power buss. The cooler shall operate within specifications as delineated herein for an input voltage between +26.0 Vdc and + 30.0 Vdc.

In addition, ripple on the supply line of 1 volt peak-to-peak, 20 Hz - 20 kHz, shall not cause performance degradation.

The cooler shall withstand input voltages of 24.0 Vdc or +32.0 Vdc with recovery to 28.0 ± 2.0 Vdc within 1 second without damage.

Transient voltage spikes of up to +50 V and -50 V with a maximum duration of $10 \mu\text{second}$ on the power input line shall not cause damage to the cooler nor cause cooler operation outside specifications.

Total power interruptions of up to 30 msec duration shall not cause degradation of cooler performance.

Steady state power consumption shall not exceed 90 watts for an input voltage of +28.0 Vdc with a design goal of 60 watts at 28.0 Vdc.

2.2 COOLING CAPACITY

The cooler shall supply 750 milliwatts of net cooling power at a cold tip temperature of 77°K max. The cooler shall perform as stated for the power input conditions of paragraph 2.1 and during environmental conditions in paragraph 2.8.1. The 750 milliwatts of net cooling power does not include thermal losses of the cold head structure or assembly.

2.3

COOL-DOWN TIME

The cool-down time shall not exceed 20 minutes under the following conditions.

- a. Initial heat sink and ambient temperature shall be $305^{\circ}\text{K} \pm 1^{\circ}\text{K}$.
- b. A 12 gram mass of copper and an electrical resistor shall be attached to the cold tip during cool-down. The total heat load on the cold tip due to radiation, lead conduction, and power dissipation in the resistor shall be 400 mw at 77°K .
- c. The temperature shall be monitored at the detector mounting position.
- d. Ambient pressure shall be $\leq 10^{-4}$ torr.
- e. Input voltage shall be limited to +28 Vdc maximum.
- f. Input power shall not exceed 90 watts at any time during the 20 minute cool-down period.
- g. Cooldown time shall be measured as the time when unit power is applied to the time when the temperature of the cold tip reaches 77°K .

2.4 HEAT SINK TEMPERATURE

The cooler shall operate within specifications for heat sink temperatures from 10°C to 53°C.

2.5 CONFIGURATION

The configuration of the cooler shall be as shown in BEI drawing 641114. Cold tip is to be 1.968" long, less than 1.000" in diameter. A copper tube of following dimensions shall be attached to the cold tip: length = 0.400"; O.D. = .660"; I.D. = .5810 \pm .0002. Mounting flange shall have 8 #6-32 x 3/16 DP Holes on a 2.250 BC.

2.6 WEIGHT

Total weight of the cryogenic cooler shall be less than 10 pounds.

2.7 VIBRATION

During continuous operation within design limits specified herein, rigidly mounted to a 30 lb. mass, the self-induced peak-peak amplitude vibration of the cold tip in any direction shall not exceed .0005". During Cooldown, length of the cold tip shall not change by more than .005".

2.8 ENVIRONMENTAL REQUIREMENTS

2.8.1 Environmental conditions under any combination of which the cryogenic cooler shall operate within specifications are as follows:

- a. Heat sink temperature 10°C to 53°C.
- b. Atmospheric pressure 10^{-8} torr to 1 atmosphere.
- c. EMI

The unit shall be designed to minimize EMI emission and susceptibility. Corrective action required as a result of the unit's failure to meet the EMI requirements of paragraph 2.10.5 will be the responsibility of BEI.

- 2.8.2 Environmental conditions which the cryogenic cooler must survive (non-operating) and thereafter, operate within specifications are as follows:
- Temperature: -40°C to 60°C
 - Humidity: 15 to 100% RH over a temperature range of -40°C to +70°C
 - Corrosive contaminant of 1% salt solution followed by oxygen atmosphere and humidity.
 - Shock: 1. 525 g shock spectrum as shown in Table I.
2. Standard handling Shock: 28 g peak, 11 smec duration.
 - Acceleration: 7.0 g per Paragraph 2.10.3.
 - Vehicle Dynamics: Spectrum as shown in Paragraph 2.10.2:1
 - Random Vibration: 1. 15.6 g rms,
2. 9.1 g rms. Spectra as shown in Paragraph 2.10.2.2

TABLE I - SHOCK CRITERIA

<u>Frequency</u>	<u>Shock Level</u>
11 —————> 20 Hz @	6.9g-peak
20 —————> 1600 Hz @	+6 db/octave
1600 —————> 5000 Hz @	525 g-peak
5000 —————> 10000 Hz @	-4 db/octave
10000 Hz @	330 g-peak

(Q = 10)

2.9 LIFETIME REQUIREMENT

The cooler shall be designed to achieve a minimum MTBF of 500 operating hours (with a design goal of 3000 operating hours).

The cooler shall operate without maintenance for a minimum of 500 operating hours, or 3 years, whichever comes first.

The cooler shall have a minimum storage lifetime without maintenance of 3 years, the last 8 months of which shall be orbital storage on the exterior of a spacecraft in a space environment.

2.10 QUALIFICATION TESTING

Block Engineering, Inc. will, at its option, conduct a full program of qualification testing on the first delivered unit. The qualification test program will be as specified in the following paragraphs of Section 2.10.

2.10.1 SHOCK

1) 525 g shock spectrum.

The qualification unit shall be shock tested with the following shock spectrum:

12.5 → 20 Hz @ 6.9g's peak
20 → 1600 Hz @ +6 db/octave
1.6 → 5 KHz @ 525 g's peak
5 → 10 KHz @ -4 db/octave
10 KHz @ 330 g's peak

(Q =10)

Unit shall be shocked 3 times/direction (18 total).
This shall be a non-operating test.

2) 28 g, 11ms shock pulse.

The test unit will be subjected to a 28 g, 11 ms shock test as specified in MIL-STD-810B, Method 516.1, Procedure I, Figure 516.1-1. The unit shall be shocked 3 times/direction (18 total). This shall be a non-operating test.

2.10.2 VIBRATION

2.10.2.1 VEHICLE DYNAMICS SIMULATION

A vehicle dynamics simulation shall be conducted prior to any other vibration test. The unit will be subjected to the following vibration profile in each axis:

5-7 Hz @ .52 in. d.a. disp.
7-15 Hz @ 1.3 g's peak
15-20 Hz @ .11 in. d.a. disp.
20-40 Hz @ 2.3 g's peak

Sweep rate shall be \leq 3 octave/min. This shall be a non-operating test.

2.10.2.2 RANDOM VIBRATION

The hardware shall be subjected to the spectra below in each of three orthogonal axes. One of the axes shall be the one considered the most critical for the hardware. Random vibration system equalization shall be accomplished and demonstrated by using "random spectrum analysis" technique, using 50 Hz or less analyzing filters. Peaks and notches may not deviate by more than \pm 1.5 db below 300 Hz and \pm 3 db from 300 Hz to 2000Hz. These tolerances are increased in all regions of the spectrum by \pm .1 db for every one db down from the maximum level specified. Variance from these requirements may be allowed only with the concurrence of the cognizant Block Engineering, Inc. test monitoring engineer present at the time of test.

The random vibration profile shall be:

- 1) 20 \longrightarrow 80 Hz @ +10 db/octave
 80 \longrightarrow 130 Hz @ 0.95 g²/Hz
 130 \longrightarrow 210 Hz @ -3 db/octave
 210 \longrightarrow 300 Hz @ 0.57g²/Hz
 300 \longrightarrow 1300 Hz @ -10 db/octave
 1300 \longrightarrow 2000 Hz @ .0038 g²/Hz

This level shall be applied for 1 min/axis with an overall level of 15.6 g rms. This shall be a non-operating test.

- 2) 20 \longrightarrow 130 Hz @ .187 g²/Hz
 130 \longrightarrow 220 Hz @ -6 db/octave
 220 \longrightarrow 800 Hz @ .063 g²/Hz
 800 \longrightarrow 1400 Hz @ -12 db/octave
 1400 \longrightarrow 2000 Hz @ .0063 g²/Hz

This level shall be applied for 4 min/axis with an overall level of 9.1 g rms. This shall be a non-operating test.

2.10.3 ACCELERATION

The test unit shall be acceleration tested per MIL-STD-810B, Method 513, Procedure I. The test levels shall be 7.0 g's for all axes. This shall be a non-operating test.

2.10.4 THERMAL CYCLING

The test unit shall be thermally cycled and on-off cycled to accumulate 200 hours operating time. During this test the heat sink temperature will be maintained between the limits of 10°C and 53°C and the duty cycle will not exceed 75%. The test unit is required to operate within specifications during this test. Motor current, and voltage are to be monitored during this test.

2.10.5 EMI

The test unit shall be subjected to the following tests as specified in MIL-STD-461 and MIL-STD-462, Class 1 D equipment.

<u>METHOD</u>	<u>TEST</u>
CE01	Conducted Emission 30 Hz to 20 KHz Power Leads
CE02	Conducted Emission 30 Hz to 20 KHz Control & Signal Leads
CE03	Conducted Emission 20 KHz to 50 MHz Power Leads

CE04	Conducted Emission 20 KHz to 50 MHz Control & Signal Leads
CE05	Not applicable as this test is covered in CE01, CE02, CE03 and CE04
CS01	Conducted Susceptibility 30 Hz to 50 KHz Power Leads modified to a frequency range of 20 Hz to 20 KHz and the amplitude shall be 2 volts peak-to-peak in place of the 3 volts rms limit.
CS02	Conducted Susceptibility 50 KHz to 400 MHz Power Leads
CS06	Conducted Susceptibility Spike Power Leads - modified to ± 50 volts, 10 microsecond transients.
RE02	Radiated Emission 14 KHz to 10 GHz Electric Field
RS01	Not applicable.
RS02	Not applicable.
RS03	Radiated Susceptibility 14 KHz to 10 GHz Electric Field
RS04	Not applicable.

The procedures followed for this testing shall be in accordance with MIL-STD-461 and MIL-STD-462.

2.10.6 Proof and Burst Pressure Test

All units are to be proof tested at 1.5 times peak operating pressure. In addition a mockup configuration similar in external construction to the qualification unit is to be burst tested at 2.0 times peak operation pressure. These tests are to be done by the cooler vendor.

2.11 ACCEPTANCE TESTING

Every unit shall pass acceptance testing before delivery. In addition, the qualification unit shall pass functional testing both immediately before and directly after passing the full qualification test program.

Each unit shall operate for a minimum of 20 hours within specifications, with no failure, prior to acceptance testing. This shall be documented in the equipment log.

As specified in paragraph 4.2.4, full Acceptance Test Procedures shall be prepared by the cooler manufacturer and submitted to Block Engineering, Inc. for approval. They shall prescribe specific procedures to verify every aspect of Cooler Configuration and performance.

As a minimum, the functional portion of acceptance testing shall consist of the following:

- a. Heat sink temperature shall be controlled at a nominal temperature of 305°K.

- b. deleted
- c. Under conditions specified in (a) above the cool-down time shall meet the specification of paragraph 2.3.
- d. After cool-down of the cold head to 77°K max., the heat sink temperature shall be reset and controlled at $50 \pm \frac{1}{3}$ °C (except the qualification unit which will be heat sunk at $53 \pm \frac{1}{3}$ °C).
- e. Under conditions specified in (d) above, and with a parasitic heat load of .75 watt attached to the face of the cold head, the cooler shall meet the requirements of paragraph 2.2 for a period of at least 4 hours of continuous operation.
- f. Vibration of the cold head during cooler operation shall be measured and meet the specification of paragraph 2.7.
- g. The helium leak rate shall be measured at an ambient temperature of 25 ± 5 °C, and shall meet the specification of paragraph 2.9.

2.12 FAILURE

- 2.12.1 Failure shall be defined as the inability of the unit to meet one or more of the design specifications delineated herein, and shall be cause for rejection of the unit.
- 2.12.2 In case any unit exhibits failure during acceptance testing, then the unit shall be repaired by the manufacturer as rapidly as possible and be re-submitted for another full acceptance test. All such failures shall be reported to Block Engineering, Inc. as specified in paragraph 4.2.6.
- 2.12.3 Functional tests to determine whether the qualification unit is performing within specifications shall be conducted before and after each environmental exposure. These tests shall be as prescribed in paragraph 2.11 (Acceptance Testing) with the following exceptions: (1) the 4 hour period specified in (e) shall be reduced to 15 minutes; (2) the helium leak rate shall not be measured; however, the pre-qualification functional test and the post-qualification functional test shall run the full 4 hour period, and shall include measurement of the helium leak rate.

Failure of the unit to pass any functional test shall constitute a failure of the qualification test, and qualification testing will be halted at that point until the unit has been repaired and/or re-designed as necessary by the manufacturer. After repair, the unit shall be required to pass the full qualification test program. All subsequent failures shall be handled in the same manner through as many iterations as necessary until the unit has passed the full qualification test program uninterrupted by failure.

2.13

ACCEPTANCE

Block Engineering, Inc. shall accept delivery within 60 days after delivery for the qualification unit and 30 days after delivery for all other units. In the case of the qualification unit, this means that Block Engineering, Inc. will accept final delivery of that unit after the post-qualification acceptance test has been passed. The cooler manufacturer shall be fully responsible and shall accomplish the repair and/or re-design necessary to upgrade the unit so that it will pass the full qualification test.

Acceptance of any and all units shall be contingent upon successful completion of the full qualification test conducted upon the qualification unit.

3.0

GENERAL DESIGN AND CONSTRUCTION REQUIREMENTS

Hardware design shall adhere to known state-of-the-art configurations and to the selection of proven parts, materials, and processes to the degree practical.

3.1

MECHANICAL

3.1.1

SAFETY FACTORS

3.1.1.1 STRUCTURAL

A safety factor of 1.50 shall be used as the standard value in structural design to determine ultimate loads. Ultimate loads are limit loads multiplied by the safety factor. The basic values for material allowable design stresses are as defined by MIL-HDBK-5. Limit loads are defined as the maximum calculated loads that will be experienced by the hardware under conditions specified herein. At limit load, yielding or excessive elastic deformation shall not occur.

3.1.1.2 FLUID SYSTEMS (Gas and Liquid)

The safety factors for fluid systems shall be as follows: ("Maximum Operating Pressure" as used in this paragraph is defined as maximum operating or surge pressure, whichever is greater).

- a. High Pressure Systems - High Pressure Systems (over 5 psi) and their components shall be designed to withstand a proof pressure equal to 1.5 times the maximum operating pressure, and a burst pressure equal to 2.0 times the maximum operating pressure.

3.2 ELECTRICAL AND ELECTRONIC

3.2.1 WIRE SPLICING

Splicing of wires shall not be allowed.

3.2.2 WIRE BUNDLE AND HARNESS PROTECTION

All wire bundles and harnesses shall be designed to withstand anticipated handling and operating deformations without damage to wires, insulation, or electrical connections. Wire smaller than 22 gauge shall not be used in wire bundles. Routing and installation of wire bundles and harnesses shall be specified on the drawings. Special precautions shall be taken to prevent damage as a result of extreme temperature conditions, chafing, or any other conditions which may result in damage.

3.2.3 GROUNDING

The insulation^{resistance} between cooler chassis ground and power ground (+28 V return) shall be not less than 1.0 Megohm.

3.3 DEBRIS PROTECTION

Hardware shall be designed so that malfunctions or inadvertant operation cannot be caused by exposure to conducting or non-conducting debris or foreign material floating in a gravity-free state.

- a. Electrical circuitry shall be designed and fabricated to prevent unwanted current paths being produced by such debris. Critical electrical items shall be provided with suitable containers, potting, or conformal coating.
- b. Threaded fittings and fasteners such as nuts, nut plates, bolts, etc. shall be designed to minimize the generation of metallic parts or foreign materials and shall be applied in a manner to preclude the release of particles or foreign material.
- c. Critical mechanical items shall be fitted with debris-proof covers or containers wherever practical.

3.4 CLEANLINESS

Hardware shall be designed, manufactured, assembled, and handled in a manner to insure the highest practical level of cleanliness. Suitable precautions shall be taken to insure freedom from debris within the cooler. Inaccessible areas where debris and foreign material can become lodged, trapped, or hidden shall be avoided insofar as practical. No dirt or contaminants of a size or location capable of causing a malfunction of the equipment under any circumstances will be present in the finished item. The outer surfaces will be free of visible dirt, soil, or hydrocarbons, as delivered. A contamination control plan for achieving these results shall be prepared as specified in paragraph 4.4.6.1 of Appendix A.

3.5 SELECTION OF SPECIFICATIONS AND STANDARDS

3.5.1 The following order of precedence shall apply in the selection of specifications and standards, except for electrical, electronic, and electromechanical parts (EEE Parts):

- a. NASA specs and standards
- b. Federal specs and standards
- c. Military specs and standards (MIL, JAN, or MS)
- d. Other Governmental specs and standards
- e. Industry specs.
- f. Manufacturer's specs

3.5.2 EEE PARTS

Design specifications for EEE Parts shall be selected from military and industrial specs which include reliability and quality assurance requirements for each application. Where adequate military and industrial specs do not exist, controlling design specs shall be prepared and shall include quality assurance and reliability requirements.

- a. Screening procedures shall be implemented for EEE parts and shall be prepared using guidelines contained in Appendix A of MSCM 5320.
- b. Design deratings for EEE parts shall be established using guidelines contained in Appendix B of MSCM 5320. These design deratings shall be based on the parts' maximum ratings which as limiting values define the electrical, mechanical, thermal, and environmental ratings beyond which either initial performance or service life of the part is impaired.

3.6 MATERIALS, PARTS AND PROCESSES

Materials, parts and processes used shall be of the highest quality compatible with technical requirements specified herein.

3.6.1 RESTRICTION ON USE OF TRANSISTORS AND CAPACITORS

Point-contact, grown junction, or alloy junction transistors shall not be used. Tantalum wet slug capacitors shall not be used in applications where exact timing or frequency stability is required. Polarized tantalum wet slug capacitors shall not be used in applications where reverse voltage is possible. Tantalum wet slug capacitors selected for use shall meet the requirements of MIL-C-3965 and shall be screened in accordance with the guidelines contained in Appendix A of MSCM 5320.

3.6.2 SOLDERING

NHB 5300.4(3A) shall apply for soldering of all electrical connections, and solder connections shall be designed to meet the quality assurance requirements of paragraph 4.4.5.4 of the AAP Experiment Hardware General Requirements (included herein as Appendix A).

3.6.3 WELDING AND BRAZING

Resistance welding (spot and seam) shall be in accordance with MIL-W-6858. Fusion welding of steel and corrosion resistant steels shall be in accordance with MIL-W-8611. Fusion welding of aluminum shall be in accordance with MIL-W-8604. Brazing shall be in accordance with MIL-B-7883.

3.6.4 Ultrasonic vibration shall not be used as a method of cleaning electronic assemblies.

3.6.5 ETCHING OF WIRE INSULATION FOR POTTING

Electrical wire or cable insulated with polytetra-fluorethylene or fluorinated ethylene propylene shall be etched prior to potting to assure mechanical bond strength and/or environmental seal. When etching of the insulation is performed, the open end of the wire shall not be exposed to the etchant. The preferred process is to form the wire into a "U" shape, immersing only the bent portion in the etchant with the open ends above the etchant level. The unetched ends of the wire are then cut off only after neutralization of the etchant. Potting shall be accomplished within three weeks after etching.

3.6.6 Adhesive bonding shall be in accordance with MIL-A-9067.

3.6.7 PARTS AND MATERIALS SELECTION

All parts and materials shall be selected from sources employing effective reliability and quality programs in their manufacture. Wherever practical parts shall be chosen which are already qualified to pertinent specifications.

3.6.8 CTi will provide a list of all external non-metallic parts to Block Engineering, Inc. for evaluation and approval.

3.7 CORROSION PREVENTION

Metals used shall be corrosion - resistant type or suitably treated to resist corrosive conditions likely to be met in manufacture, assembly, testing, servicing, storage, or normal service use. Protective coatings shall not crack, chip, peel, or scale with age when subjected to the environmental extremes specified herein. Unless suitably protected against electrolytic corrosion, dissimilar metals, as defined in MIL-STD-889 shall not be used in direct physical contact. Any protection used shall offer a low impedance path to radio frequency currents. Hardware shall be designed so that no failures will occur due to stresscorrosion resulting from exposure to specified natural and induced environments or from fluids used in or on the hardware or components of the hardware during fabrication, cleaning, flushing, inspecting, testing, or operating.

3.8 WORKMANSHIP

Workmanship shall be in accordance with the best practice for high quality equipment within the state-of-the-art.

4.0 DOCUMENTATION REQUIREMENTS

4.1 Schedule

An initial program schedule will be submitted within two weeks after receipt of contract. The schedule will show a logical breakdown of effort and include a delivery date for each deliverable item as well as all significant program milestones. It will be so arranged as to make clear the time flow and interdependence of tasks.

4.2 Reports

The following reports are to be submitted:

4.2.1 Status Reports

1. Summarize the significant technical and program progress.
2. Delineate all problems which have arisen.
3. Delineate the current status of the program with respect to the program schedule, including an updated copy of the program schedule. Indicate any changes in schedule, especially concerning delivery dates, including reasons for the changes. Indicate any changes in key personnel.
4. Define the tasks to be carried out during the next report period and make recommendations for further activity.

Such reports are to be made each month of the program.

4.2.2 Design Report

The design report should be a technical report delineating the design of each deliverable item and should include all relevant analyses, design and performance parameters and all electrical/electronic schematics and application interface drawings. The design report is to be submitted within one month after the critical design review.

4.2.3 Qualification Test Procedures

All qualification test procedures to be required for qualification testing will be prepared by Block Engineering, Inc. CTi will be extended the right to review qualification test procedures prior to start of official qualification testing.

4.2.4 Acceptance Test Procedures

A complete description of procedures to be used for acceptance tests is to be submitted for approval one month in advance of initial acceptance test.

4.2.5 Test Reports

Complete reports on test results are to be submitted within three weeks after completion of design, qualification or acceptance tests.

4.2.6 Failure and Unsatisfactory Condition Reports

Initial reports on failure or unsatisfactory conditions are to be submitted within five days after discovery of the condition. Verbal notice of such conditions is to be made within 24 hours after discovery of the condition. An initial plan for corrective action is to be included in the written report. Corrective action is to be documented in the following monthly progress reports.

In the event of a failure subsequent to delivery, full design review privileges (including access to all engineering drawings and process specs, complete vendor list and complete list of metallic materials) will be extended at CTi to a NASA/MSC designated Failure Review Board.

4.3 Configuration and Specification Changes

All conditions or situations which may have a significant impact on either configuration or specification of any deliverable item are to be immediately reported verbally and if such changes are unavoidable, a formal configuration change proposal and/or specification change proposal is to be submitted and approved by BEI before such changes are incorporated into deliverable item designs.

4.4 Meetings

4.4.1 Design Review

A design review will be held at the end of the design effort at which time the design of deliverable items will be base-lined. The meeting will be attended and chaired by designated representatives of BEI and NASA/MSC. Minutes will be taken by the contractor and submitted within two weeks after the review.

ORIGINAL PAGE IS
OF POOR QUALITY

4.4.2 Qualification Tests

All qualification tests to be conducted will be attended by designated BEI and NASA/MSC R&QA personnel.

4.4.3 Acceptance Tests

Acceptance tests will be attended by designated BEI and NASA/MSC R&QA personnel and the results of such tests will be signed-off by such personnel prior to acceptance of the deliverable items.

4.5 Acceptance Data Package

The Acceptance Data Package will be submitted with the delivery of each deliverable hardware item. It will contain:

4.5.1 Final Technical Manual

The manual will specify all installation, operation, and handling procedures necessary for the use, maintenance and troubleshooting of the deliverable item.

4.5.2 Design Package

As a minimum, one reproducible updated, fully dimensional outline drawing will be submitted. A cross-section drawing identifying all materials, heat sources and average temperatures throughout the cooler will be included in the design package.

4.5.3 Operation Log

The complete operation log for each deliverable item as specified in Section 5.2.3 will be submitted with the item.

4.5.4 Acceptance Test Report

A report including results of acceptance testing will be submitted

4.5.5 Nonmetallic Materials Certification

Certification of compliance to the requirements of paragraph 3.6.8 will be submitted.

4.5.6 Contamination Control Certification

Certification of compliance with the BEI approved Contamination Control Plan will be submitted.

4.5.7 Change Log

A complete list of all approved Configuration and Specification Change Orders will be submitted.

4.6 Vendor List

A complete list of vendors supplying components for the manufacture of the cryogenic cooler will be submitted to NASA/MSD.

5.0 QUALITY ASSURANCE AND RELIABILITY

5.1 General

5.1.1 This document presents the level of Quality Assurance and Reliability effort required by subcontractors and suppliers to Block Engineering for the above listed contract.

5.1.2 The level of effort required by subcontractors who are furnishing major sub-assemblies or complete modules is described in Section 5.2.

5.1.3 This document specifies requirements in addition to any which may appear on a purchase order, but may be modified by specifically stated purchase order requirements which will take precedence.

5.2. SUBCONTRACTOR REQUIREMENTS

5.2.1 Quality Assurance Requirements

5.2.1.1 The Subcontractor will maintain, as a minimum, a Quality System conforming in all respects to Military Specification MIL-Q-9858A. Adherence to this system will be verified by BEI QA+R coverage at specified check points to be agreed upon by BEI and CTi. Access to procedures, manufacturing, and testing will be available, as required for quality verification, to BEI QA+R.

5.2.1.2 If required by the purchase order, both BEI Source Inspection and Government Source Inspection may be required, and the Subcontractor will be prepared to provide all required verification information for the Government representative.

5.2.1.3 Deleted

ORIGINAL PAGE IS
OF POOR QUALITY

- 5.2.1.4 Acceptance Testing will be required. As a minimum this will consist of testing end items to the environmental specifications delineated in Section 2.11 of the Technical Requirements. A representative of Block Engineering, Inc. will be present at Acceptance Testing and will perform Acceptance evaluation at the Subcontractor's plant prior to shipment. This will consist of a review of the instrument, all related test data, test reports, etc. This in no way relieves the Subcontractor from the necessity of performing his own inspection.
- 5.2.1.5 In the event of conflict or redundancy between sections of these purchasing specifications, the provisions of Section 5.2.1 (Quality Assurance Requirements) will govern
- 5.2.2 Reliability Requirements
- 5.2.2.1 This equipment is essential for accomplishment of a secondary mission objective for a manned orbital mission experiment. The reliable operation of the equipment is therefore of great importance, and must be verified.
- 5.2.2.2 A target MTBF for all electronic equipment of 30,000 hours has been established. Although lower values will be considered, equipment meeting this requirement will be given first consideration.
- 5.2.2.3 A target MTBF for all electrical, mechanical, and electro-mechanical equipment of 3,000 hours has been established. Although lower values will be considered, equipment meeting this requirement will be given first consideration.
- 5.2.2.4 If the equipment is capable of demonstrating the required reliability on the basis of proven reliable operation of previously manufactured identical or demonstratably similar equipment, this information should be presented to BEI, Q.A. and Reliability Department for evaluation, and may be considered sufficient to satisfy the life requirements of this spec.
- 5.2.2.4.1 If the data as required above is not available, or is deemed insufficient or otherwise unsatisfactory, then a life test under realistic operating conditions (to be specified by BEI) shall be conducted.

ORIGINAL PAGE IS
OF POOR QUALITY

- 5.2.3 A log of all operating time will be maintained on the equipment from the time it reaches final assembly. This log will contain as a minimum the following information.
 - 5.2.3.1 Complete identification of the item.
 - 5.2.3.2 The date and total time run.
 - 5.2.3.3 The reason for operation (test, set-up, adjustment, etc.).
 - 5.2.3.4 The results of the operation (in-spec., adjusted, failed test, etc.).
 - 5.2.3.5 Any repairs performed.
 - 5.2.3.6 The signature of the one who performed or witnessed the operations.
 - 5.2.3.7 The completed log will be available for review at any time and will be shipped with the equipment.
- 5.2.4 Any test failures occurring during acceptance or qualification testing must be fully documented and definite correcting action must be defined and documented.
- 5.2.5 The equipment covered by this specification shall be handled in such a manner during manufacturing that no dirt or contaminants of a size or location capable of causing a malfunction of the equipment under any circumstances will be present in the finished item. The outer surfaces will be free of visible dirt, soil, or hydrocarbons, as delivered.
- 5.2.6 Deleted
- 5.2.7 All items must be fully sealed units. Electrical connectors will meet the following requirements.

- 5.2.7.1 Electrical circuits shall not be routed through adjacent pins of a connector if a short circuit between them could constitute a source of failure for the connected system.
- 5.2.7.2 Cable connections shall be designed so that pin and socket connectors are properly used to prevent power from shorting to ground. They also shall be designed to protect personnel both when connected and disconnected, and, during the operations of connection and disconnection.
- 5.2.8 CTi shall identify each completely assembled cooler with a unique serial number.
- 5.2.9 Each piece of supplied equipment shall be so designed that it will not be damaged by the application of power of reverse polarity.
- 5.2.10 Each piece of supplied equipment shall be so designed that any testing required during normal set-up and check-out can be accomplished at available test points with no necessity for disconnecting or probing connectors.
- 5.2.11 Each piece of supplied equipment shall be packaged for shipment in a manner to insure cleanliness and physical protection in shipment.
- 5.2.12 Established reliability components shall be used wherever possible.
- 5.2.13 Design Review Program
 - 5.2.13.1 The standards and reliability programs of the Subcontractor are subject to continuous examination, evaluation, and inspection by the Manned Spacecraft Center or its designated representative. These programs shall be reviewed by Block Engineering, Inc.
 - 5.2.13.2 A formal program of planned, scheduled, and documented design reviews shall be established. These reviews shall be comprehensive audits of all pertinent aspects of design, particularly milestones beginning at the feasibility stage. These design reviews shall form a part of the comprehensive Block Engineering Reliability Plan as required by provisions of NASA contract NAS-9-10975.

ORIGINAL PAGE IS
OF POOR QUALITY

5.2.13.3 Participation in the design reviews shall include personnel from:

1. Block Engineering, Inc.
2. NASA/MSC
3. Design
4. Fabrication
5. Reliability
6. Quality
7. Parts Application
8. Safety
9. Test
10. Etc., as applicable

6.0 DELIVERY

- 6.1 The first unit to be fabricated and delivered shall be the Qualification unit. This unit will be delivered initially to Block Engineering, Inc. for qualification testing. Final acceptance will be after successful completion of the full qualification test program.

Any and all design changes found necessary for the qualification unit shall be incorporated into all subsequently delivered units.

- 6.2 One Acceptance Data Package, as specified in Section 4.5, shall be delivered with the initial delivery of the qualification unit.

The delivery of each subsequent unit shall be accompanied by a similar set of documentation.

PROCUREMENT SPECIFICATIONS FOR HgCdTe RADIATION DETECTORS

1.0 INTRODUCTION

This document describes the required configuration and performance characteristics of tri-metal HgCdTe detectors to be used in the Infrared Spectrometer Experiment S191 of the Earth Resources Experiment Package, being developed by Block Engineering, Inc. under NASA Contract NAS-9-10975. Quality Assurance, Reliability, lifetime and documentation requirements are also specified.

The system is for use in manned space flight. Materials, manufacturing, and workmanship of highest quality standards are essential to astronaut safety. If you are able to supply the desired items with a quality which is higher than that of the items specified or proposed, you are requested to bring this fact to the immediate attention of the purchaser.

1.1 General Description

The detectors specified herein correspond to Texas Instruments part numbers MCT-70 and MCT-71. They shall be required to operate at a temperature of 77°K over the spectral region from 6.2 to 15.5 micrometers (μ). The optically sensitive area shall be square and its field of view shall be restricted by a cold shield to 55° x 55° in the manner specified in paragraph 2.1.4. These detectors will be supplied permanently mounted in an evacuated dewar assembly as defined in paragraph 2.3.1.

1.2 Definition of Performance Parameters

The definitions of performance and design parameters of this specification are contained in "Standard Procedures for Testing Infrared Detectors and Describing their Performance" by R. C. Jones et.al., 12 September 1960, published by Director of Defense Research and Engineering (DDRE) , Washington, D. C.

2.0 TECHNICAL REQUIREMENTS

2.1 Mechanical

2.1.1 Material

The optically sensitive material shall be photoconductive HgCdTe.

2.1.2 Size

The optical area, measured mechanically, shall be 0.625 x 0.625 mm square with a tolerance of ± 0.025 mm.

2.1.3 Optical Area

The optical area used in the D^* calculation shall be measured mechanically.

2.1.4 Field of View

The field of view shall be restricted by a cold shield to $55^\circ \times 55^\circ$. The field of view in one plane shall be symmetrical around the normal to the plane of the optical area. However, the field of view in the orthogonal plane shall be directed at an angle of 7° from the normal. That is, the field of view in that plane shall include 34.5° on one side of the normal and 20.5° on the other side of the normal. Tolerance on all angles in this paragraph shall be $\pm 2^\circ$. Refer to Figure I, sheet 16, for additional data.

2.2 Electrical

2.2.1 Detectivity

The peak D_{λ}^* shall be determined using the following parameters:

Wavelength: λ at peak detectivity

Chopping frequency: 3 kHz

Electrical bandwidth: 1 Hz

Field of View: $55^\circ \times 55^\circ$

Temperature: 77°K

2.2.1.1 Peak D_{λ}^* for MCT-70

TI part number MCT-70 detectors shall exhibit peak $D_{\lambda}^* \geq 1.5 \times 10^{10}$ cm-Hz^{1/2}/watt, as measured using the parameters specified in paragraph 2.2.1.

2.2.1.2 Peak D_{λ}^* for MCT-71

TI part number MCT-71 detectors shall exhibit peak $D_{\lambda}^* \geq 2.0 \times 10^{10}$ cm-Hz^{1/2}/watt, as measured using the parameters specified in paragraph 2.2.1.

2.2.1.3 Short Wavelength Detectivity

The detectivity at $\lambda = 6.2\mu$ shall be as follows:

$$D_{\lambda}^* \geq 7.5 \times 10^9 \text{ cm-Hz}^{1/2}/\text{watt for MCT-70 detectors.}$$

$$D_{\lambda}^* \geq 1.0 \times 10^{10} \text{ cm-Hz}^{1/2}/\text{watt for MCT-71 detectors.}$$

These values to be determined using the parameters (except λ) as specified in paragraph 2.2.1.

2.2.1.4 Long Wavelength Detectivity

The detectivity at $\lambda = 15.5\mu$ shall be as follows for both MCT-70 and MCT-71 detectors:

$$D_{\lambda}^* \geq 33\% \text{ of peak } D_{\lambda}^*$$

Value to be determined using the parameters (except λ) as specified in paragraph 2.2.1.

2.2.1.5 Peak Spectral Response

Detectors shall be designed for $\lambda = \lambda_p$ at peak detectivity consistent with the requirements of paragraph 2.2.1.3 and 2.2.1.4.

2.2.1.6 Detectivity at 90°K

The specified D_{λ}^* at a detector operating temperature of 90°K shall be greater than or equal to 60% of the corresponding D_{λ}^* specified at 77°K, for all specified wavelengths.

2.2.2 Responsivity and Optimum Bias Current

The measured responsivity shall be greater than or equal to 700 volts/watt at a temperature of 77°K. The optimum bias current shall not exceed 20 milliamperes.

2.2.3 Resistance

The detector resistance at a temperature of 77°K shall be greater than or equal to 20 ohms, but shall not exceed 100 ohms.

2.2.4 Detector Response Time

The detector response time shall be less than 20 microseconds.

2.3 Dewar

The detectors specified herein shall be used in conjunction with Malaker Mark XV Cryogenic Coolers. The dewar design shall be compatible with the cooler configuration. The main dewar body shall be of glass construction.

2.3.1 Dewar Configuration

The dewar configuration shall conform to a design specified or approved by Block Engineering, Inc. The design shall be completely specified no less than 60 days prior to delivery of the first unit to Block Engineering, Inc.

2.3.2 Dewar Window

The dewar window shall be uncoated IRTRAN-6. Block Engineering, Inc., at its option, may decide to change the window material and/or coating at any time until the final dewar design is completely specified. Any change in window transmission resulting from such decisions shall be directly reflected in the D_{λ}^* specifications of paragraphs 2.2.1.1 through 2.2.1.4.

2.3.3 Thermistor

Two calibrated thermistors shall be supplied for monitoring detector temperature. The choice of thermistors and their mounting configuration shall be specified or approved by

Block Engineering, Inc. The transfer characteristic (temperature vs resistance) shall be calibrated to an accuracy of $\pm 0.5^\circ\text{K}$ for each thermistor between 70°K and 120°K .

2.3.4 Ground Plane

An electrically isolated ground plane shall be provided. It shall be located between the detector and the cold tip of the cooler, electrically insulated from both. Provision shall be made for electrical connection to the ground plane from outside the dewar. The cold shield shall be electrically connected (grounded) to the ground plane.

2.3.5 Feedthrough Pins

Provision shall be made for making the following electrical connections from outside the dewar:

- a. Two pins connected to detector leads.
- b. Four pins connected to thermistor leads.
- c. One pin connected to ground plane lead.

All feedthrough pins shall be gold plated or otherwise treated to facilitate soldering of leads thereto.

The exact configuration of leads will be approved along with final dewar design not later than 60 days before delivery.

2.3.6 Grounding

The insulation resistance between all electrically isolated points associated with the detector-dewar assembly shall be at least 10 Megohms for both +56 and -56 volts potential. Specifically all the following pairs of points shall be so isolated:

- a. Ground plane and any part of dewar.
- b. Ground plane and either detector lead.
- c. Ground plane and any thermistor lead.
- d. Each detector lead and any part of dewar.
- e. Each detector lead and any thermistor lead.
- f. Each thermistor lead and any part of dewar.

2.3.7 Dewar Vacuum

The vacuum integrity of the dewar shall be guaranteed for a minimum of 6 months following delivery.

2.4 ENVIRONMENTAL REQUIREMENTS

2.4.1 Operating Environment

Ambient environmental conditions under which the detector-dewar assembly shall operate within specifications are as follows:

- a. Any ambient temperature from 0°C to +50°C inclusive.
- b. Any ambient pressure from 1 atmosphere to 10^{-8} torr inclusive.

2.4.2 Survival Environment

The ambient environmental conditions which the detector-dewar assembly shall survive (non-operating) and thereafter operate within specifications are as follows:

- a. Temperature: -40°C to +50°C.
- b. Humidity: 15 to 100% RH over a temperature range of -40°C to +50°C.
- c. Corrosive contaminant of 1% salt solution followed by oxygen and humidity (CCOH).
- d. Shock: 20 g peak, 11 msec duration.
260 g peak damped sine wave, decay ratio per cycle = 1/300; period = 0.75 msec.
- e. Acceleration: 7 g
- f. Sinusoidal vibration: 3 g peak, 20-2000 Hz.
- g. Random vibration: 11.3 g rms, 20-2000 Hz.

2.4.3 Operating Note

The conditions specified in sections 2.4.1 and 2.4.2 above are not to be construed in any way to apply to the operating temperature of the detector element at the cold tip of the cryogenic cooler, which may attain temperatures as low as 60°K locally.

3.0 QUALIFICATION TESTING

Block Engineering, Inc. will, at its option, conduct a full program of qualification testing on the first delivered unit. The qualification test program will be as specified in the following paragraphs of Section 3.0.

3.1 Shock

The qualification unit shall be shock tested in accordance with MIL-STD-810B, Method 516, Procedure I. The shock pulse shape shall be as shown in Figure 516-1. The peak value shall be 20g's and the nominal duration shall be 11 milliseconds. This shall be a non-operating test.

3.2 Vibration

3.2.1 Sinusoidal Resonance Search

A sinusoidal frequency search shall be conducted prior to any other vibration test. Resonant frequencies of the test specimen shall be determined by sweeping through the frequency range of the test specimen from 20 Hz to 2000 Hz at a 3g peak. The amplitude of excitation shall be modified at each resonant point, applying only sufficient energy to allow determination of the resonant frequency and its observed amplification factor (Q). The search shall be a logarithmic sweep from 20 Hz to 2000 Hz at no faster than 2 minutes per octave, so that all significant resonances may be recognized and recorded. This shall be a non-operating test.

3.2.2 Random Vibration

The hardware shall be subjected to the spectrum below in each of three orthogonal axes. One of the axes shall be the one considered the most critical for the hardware. Random vibration system equalization shall be accomplished and demonstrated by using "random spectrum analysis" technique, using 50 Hz or less analyzing filters. Peaks and notches may not deviate by more than ± 1.5 db below 300 Hz and ± 3 db from 300 Hz to 2000 Hz. These tolerances are increased in all regions of the spectrum by ± 1 db for every one db down from the maximum level specified. Variance from these requirements may be allowed only with the concurrence of the cognizant Block Engineering, Inc. test monitoring engineer present at the time of test.

The random vibration profile shall be:

20	→	80 Hz	@	+10 db/octave
80	→	130 Hz	@	$0.5 \text{ g}^2/\text{Hz}$
130	→	210 Hz	@	-3 db/octave
210	→	300 Hz	@	$0.3 \text{ g}^2/\text{Hz}$
300	→	1300 Hz	@	-10 db/octave
1300	→	2000 Hz	@	$.002 \text{ g}^2/\text{Hz}$

This level shall be applied for 1 min/axis with an overall level of 11.3g rms. This shall be a non-operating test.

3.3 Acceleration

The test unit shall be acceleration tested per MIL-STD-810B, Method 513, Procedure I. The test levels shall be 7.0g's for all axes. This shall be a non-operating test.

3.4 Altitude

The test unit shall be temperature-altitude tested in accordance with MIL-STD-810B, Method 500, Procedure II, with the following changes. The test chamber internal temperature shall be lowered to 4°C in Step 2. The test chamber internal pressure shall be lowered to 10^{-6} torr or lower in Step 4. Step 5 shall be performed, and upon completion of Step 5, the temperature shall be raised to 50°C with the unit operating. The unit shall operate at 50°C for a period of one hour following stabilization. Step 7 shall be altered to consist of returning the unit ambient temperature to room ambient. The test unit is required to operate within specification during this test.

4.0 QUALITY ASSURANCE AND RELIABILITY REQUIREMENTS

- 4.1 The detector manufacturer shall maintain a quality program conforming in all respects to MIL-Q-9858A.
- 4.2 Government Source Inspection may be required. The detector manufacturer shall be prepared to provide all required verification information for the Government representative.
- 4.3 Each detector shall be handled in such a manner during fabrication that no dirt or contaminants capable of causing a malfunction under any conditions (including zero g condition in space) will be present in the finished item. The outer surfaces shall be free of visible dirt, soil, or hydrocarbons, as delivered.
- 4.4 Each detector supplied shall be identified with a unique serial number.
- 4.5 Each detector shall be packaged for shipment in a manner to insure cleanliness and physical protection in shipment and during storage.
- 4.6 Sufficient data will be kept on file by the manufacturer documenting materials and manufacturing processes to provide for the effective reproduction of the items shipped. This data will be retained for a minimum of five (5) years.
- 4.7 Acceptance of each item will be at Block Engineering, Inc. following review of all acceptance data.
- 4.8 Failure of the first delivered unit (excluding dewar failure) to survive qualification test stress environments will be handled in the following manner: The detector manufacturer shall be fully responsible and shall accomplish the repair and/or re-design necessary to upgrade the unit so that it will pass the full qualification test. Any and all design changes found necessary as a result of qualification testing shall be incorporated into all units delivered subsequent to qualification testing. The detector manufacturer shall, as necessary, perform the work indicated in this paragraph as rapidly as possible, and at no additional cost to Block Engineering, Inc.

4.9 The manufacture by the subcontractor of any mechanical or electromechanical deliverable items under this purchase order will be accomplished in accordance with the requirements of MIL-Q-9858A and will include drawing controls, test and inspection equipment calibration control, and manufacturing process control.

4.10 If any items supplied under this purchase order are procured from another vendor, the subcontractor on whom Block Engineering has placed this order assumes responsibility for the conformance by that vendor to all applicable requirements defined herein.

5.0 LIFETIME REQUIREMENTS

5.1 Guaranteed Operation

Each detector shall operate within specifications as defined herein for a period of not less than 6 months after delivery to Block Engineering, Inc. Moreover, the detector manufacturer shall re-pump the vacuum on the detector dewar whenever necessary up to one year after delivery to Block Engineering, Inc. at no additional cost.

5.2 Design Lifetime

The detectors shall be designed to operate within specifications following a storage period of up to 3 years after delivery, the last 8 months of which shall be orbital storage on the exterior of a spacecraft in a space environment. Provisions for re-evacuation of the dewar during the 3 year storage period as required shall be made.

6.0 MEASUREMENTS FOR ACCEPTANCE

The following measurements and/or calculations shall be carried out on each detector by the manufacturer:

- a. Mechanical measurement of optical area
- b. Mechanical measurement of field of view
- c. Peak D_{λ}^* , associated D_{BB}^* , and signal/noise measurements
- d. Spectral response curve from 6.2μ to 15.5μ
- e. Responsivity
- f. Detector resistance at operating temperature of 77°K
- g. Detector noise vs. bias current at a chopping frequency of 3 KHz.
- h. Characteristics of preamplifier used in measurements
- i. Recommended optimum bias current.

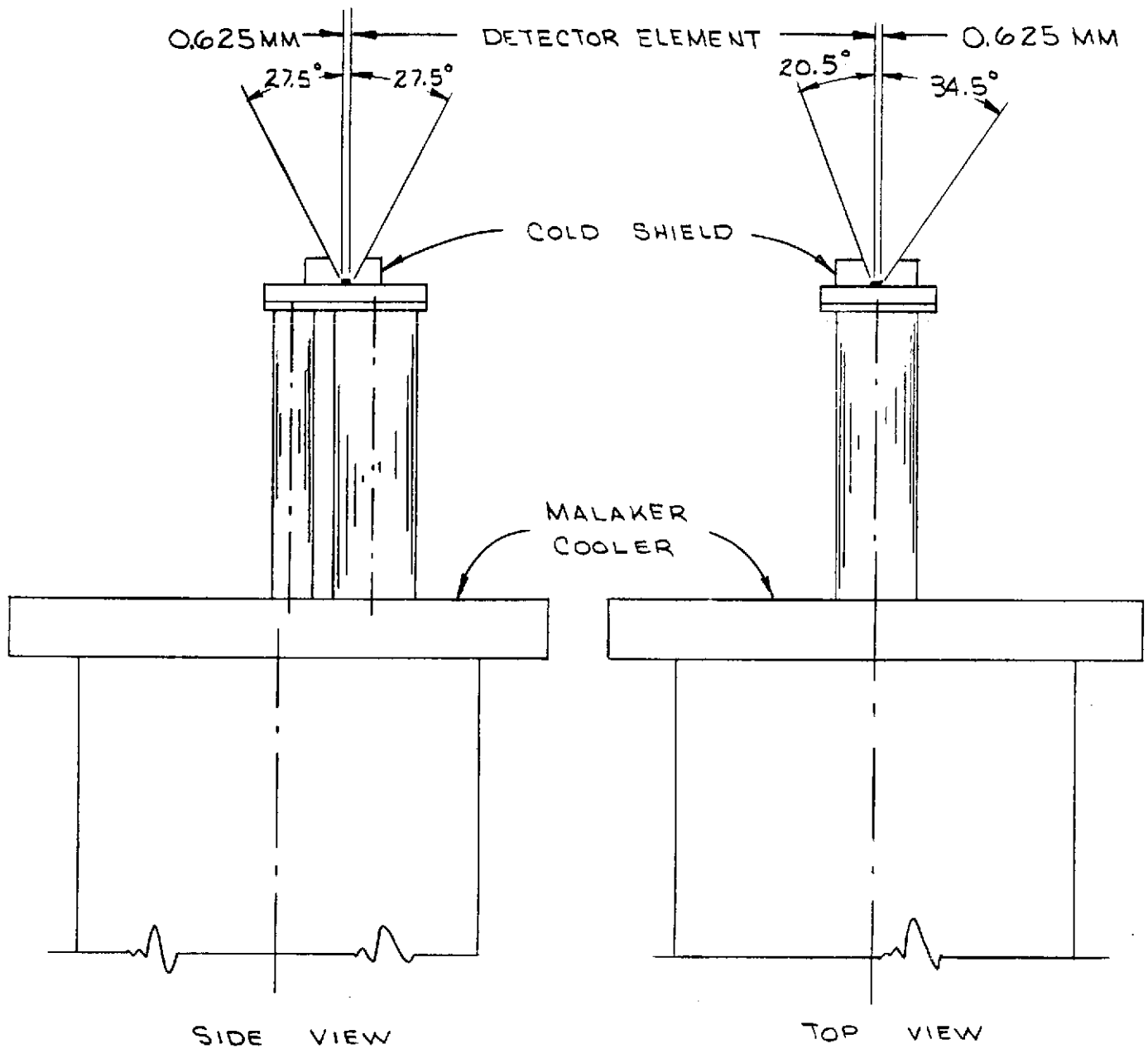
All performance measurements that depend on dewar window transmission shall be carried out using the dewar window specified by Block Engineering, Inc. for final dewar design.

7.0 DOCUMENTATION

The following documentation shall be furnished by the detector manufacturer with delivery of each detector:

- a. Results of all the measurements described in Section 6.0 above, along with a description of the methods used.
- b. Thermistor calibration data for all temperatures between 60°K and 120°K.
- c. Thermistor calibration data for temperatures between 120°K and 300°K accurate to ±10°K.

7.1 All documentation supplied for thermistor calibration will be in the form of a transfer function obtained by using Block Engineering test circuit No. 32782043. No evidence of calibration traceability is required for this data.



ORIGINAL PAGE IS
OF POOR QUALITY

FIGURE 1

Orientation of Detector Field
of View with Respect to Mounting
on Malaker Cooler

Appendix B

Listing of Reference Data

The following documents provide detailed information in the various areas indicated, and are listed here as reference to provide a complete description of the program. All of these documents have been submitted to NASA.

Program Documents

<u>Document No.</u>	<u>Title</u>
B-S191-101001	Management Plan, Section I General Management
B-S191-101002	Management Plan, Section II Quality Program Plan
B-S191-101003	Management Plan, Section III Reliability Program Plan
B-S191-101004	Management Plan, Section IV Configuration Management
B-S191-101005	Management Plan, Section V Test Management
B-S191-101006	Management Plan, Section VI Logistics Support
B-S191-101007	Management Plan, Section VII Manufacturing Plan
B-S191-101008	Management Plan, Section VIII Development Schedule
B-S191-101009	Management Plan, Section IX Non-Metallic Materials Plan
B-S191-101010	Management Plan, Section X System Safety Plan

System Specifications

B-S191-102001	End Item Specification Integration Functional Test Unit
B-S191-102002	End Item Specification Mechanical Fit Check Unit

B-S191-102004	Data Sheet Ground Support Equipment
B-S191-102005	Data Sheet Modified GSE
B-S191-102006	Data Sheet On-Module Calibrator

Configuration Specifications

B-S191-103001	Configuration Specification Section I, Flight Hardware
B-S191-103003	Configuration Specification Section II, Flight Hardware
B-S191-103004	Configuration Specification Sections III and IV, Flight
B-S191-103005	Configuration Specification Section II(a), Flight
B-S191-103006	Configuration Specification Section II(b), Flight
B-S191-103007	Configuration Specification Section II(c), Flight

Test Reports, Development

B-S191-104001	Development Test Report Wedge Filter Shock Test
B-S191-104002	Development Test Report Heated Cal. Source Temp. Control
B-S191-104003	Development Test Report Ref. Source Temp. Control
B-S191-104004	Development Test Report Dichroic Performance
B-S191-104005	Development Test Report Input-Output Document
B-S191-104006	Development Test Report Sandwich Detector Test
B-S191-104007	Development Test Report Foreoptics System
B-S191-104008	Instrument Field of View

B-S191-104009	S-191 System Performance
B-S191-104010	Structural Design Approach
B-S191-104011	S-191 Stress Analysis
B-S191-104012	Survival under Repressurization
B-S191-104013	Pressure Vessel Burst Analysis
B-S191-104014	Thermal Vacuum Testing
B-S191-104015	Effect of Geomagnetically Trapped Radiation on S-191 Hardware
B-S191-104016	Helicopter Unit Dewar Assembly Test

Non-Metallic Materials

B-S191-105001	Preliminary Non-Metallic Materials List
B-S191-105002	Final Non-Metallic Materials List

EEE Parts Lists

B-S191-106001	Preliminary EEE Parts List
B-S191-106002	Final EEE Parts List

Manufacturing Planning

B-S191-107001	Qualification Hardware Refurbishment Analysis
B-S191-107005	Parts in Progress Schedule Flight Hardware
B-S191-107006	Parts in Progress Schedule IFTU Hardware
B-S191-107007	Parts in Progress Schedule Qualification Hardware

Test Procedures

B-S191-108001	Verification Plan Flight Hardware
B-S191-108002	Verification Plan Mechanical Fit Check Hardware

B-S191-108003	Acceptance Test Procedure Flight Hardware
B-S191-108004	Qualification Test Procedure Flight Hardware
B-S191-108005	Acceptance Test Procedure IFTU Hardware
B-S191-108006	Acceptance Test Procedure Ground Support Equipment
B-S191-108007	Preinstallation Test Procedure Flight Hardware
B-S191-108008	Calibration Test Procedure Flight Hardware
B-S191-108009	Acceptance Test Specification Ground Support Equipment Model 2
B-S191-108010	Acceptance Test Procedure On-Module Calibrator
B-S191-108011	Checkout Procedure On-Module Calibrator
B-S191-108012	Acceptance Test Procedure Helicopter Spectrometer
<u>Miscellaneous Reports & Procedures</u>	
B-S191-109001-3 109005-9 109011&12 109016&19	} Development Status Reports
B-S191-109004	Flight Hardware Spares Requirement
B-S191-109010	CDR Review Minutes, Part B
B-S191-109013	Operating Maintenance and Handling Procedures, Volume I
B-S191-109014	Same - Volume II
B-S191-109015	Same - Volume III
B-S191-109020	Design Review Assessment Report
B-S191-109021	Operating Maintenance and Handling Procedures, Helicopter Spectrometer

B-S191-109022	Minutes, S-191 Helicopter Hardware CARR
B-S191-109023	S-191 Residual Inventory Listing
<u>QA&R Documents</u>	
B-S191-401001	FMEA, Preliminary
B-S191-401002	FMEA, Final Design
B-S191-401003	FMEA, Flight Configuration
B-S191-404001	Component Qualification Test Report Malaker Cooler
B-S191-404002	Calibration Test Report Qualification Hardware
B-S191-404003	Acceptance Test Report Qualification Hardware
B-S191-404004	Qualification Test Report S-191 Hardware
B-S191-404005	Calibration Test Report Flight Hardware
B-S191-404006	Acceptance Test Report Flight Hardware
B-S191-404007	Qualification Test Report Cooling Engine Thermal Test
B-S191-404008	S-191 Program Vendor Data
B-S191-404009	Component Qualification Test Report Malaker Cooling Engine
B-S191-404010	Historical Report Malaker Cooling Engine
B-S191-404011	Calibration Test Report Helicopter Hardware
B-S191-404012	Acceptance Test Report Helicopter Hardware
B-S191-404014	Calibration Test Report Flight Backup Hardware
B-S191-404015	Acceptance Test Report Flight Backup Hardware